IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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EDITORIALS

HOW THE ELECTRICAL ENGINEER AND THE SAFETY DIRECTOR CAN BE MUTUALLY HELPFUL*

A. C. Cumminst: It is a great privilege to see such a large and representative gathering of steel mill engineers here from all over America to attend the opening of our Twentieth Annual Convention. We should congratulate ourselves in being affiliated with an organization whose representatives are so progressive and so interested in the advancement of the art which is their profession, that they spend a week of each year in deliberating over what is newest and best for improving the service they render to the greatest basic industry of the country. It therefore gives me great pleasure to call this first meeting to order.

The particular object of this meeting is Safety. It is considered an important one in the eyes of the executives of the steel industry. Many of you will remember that the last session of the Nineteenth Convention requested the Board of Directors to give a greater recognition to the fact that the steel mill engineer was becoming more and more intimately associated in the solution of the problems of industrial safety. This meeting is the answer of the Board to that resolution. Due to their efforts we have with us today, not only those of our own membership who are vitally interested in this movement, but also safety engineers of the steel industry who have kindly volunteered to assist in the work of furnishing a means for promoting closer co-operation in solving the problems of engineering and the problems of safety. It is a compliment to the achievements of the members of this body that so many of our industrial safety specialists have been willing to assist in launching this enterprise, because they hold an enviable reputation for co-operation and for accomplishment in this great field of what might be termed human engineering. And with their valuable assistance there is no question that our members will become better engineers, better safety men, and better industrial managers because of the more intimate contact with these men who deal primarily with the personal side of industry.

Perhaps a word of explanation as to the scope of the newest Section of the Association may not be amiss. Already mechanical and electrical engineers have entered into the safety movement with a spirit that reflects the enthusiasm that has so dominated the work of the safety engineer. Co-operation now exists to a point of idealism as far as individuals are concerned in the two groups, and this spirit goes even further until it embraces whole works organizations. But we all know that this is an age of correlated effort and that maximum progress in any field cannot be secured unless we combine the efforts of individuals and individual plant organizations into a systematic, well organized body, endeavoring to reach the goal of accidentless industry. What has been lacking in the steel industry is a medium where those of our engineers who are responsible for the installation and maintenance of safety devices could discuss their problems under the guidance and help of those who have made their life work the reduction of hazards to health and happiness of our workmen. Our problems are relatively specialized. They cover a limited field. They cannot be solved by generalization, and it is therefore our feeling that we will not encroach upon the activities of any other organization in asking the safety engineers of our industry to join with us, that further progress in attaining the ultimate goal may be attained more efficiently and more rapidly.

If you will permit me to illustrate some of the problems existing, I will relate an instance. An Electrical Department of a large plant does everything suggested in the way of installing safety equipment. Their gears are well guarded. Their safety switches are as safe as such devices are made, their men repeatedly drilled in the mental attitude essential to the success of the accident prevention. They operated for six months without an accident; and with about 700 men, this is not a bad record.

Yet at the conclusion of this six months' period, eight serious accidents occurred in eleven days. One man takes a chance, falls from a crane, suffering broken ribs and feet. Another climbs a rotted pole, cuts a wire and the pole falls, carrying the man with it. There are some fractured vertebrae. Still another and a most efficient worker for safety, gives too little clearance to a wire rope used in hoisting, the back lash knocks him from an ore trestle. He spends six weeks in a hospital. Two or three bad burns and a couple of minor falls, all lost time cases, completes the record. There is some cause for such a performance, yet the man trained in the solving of engineering problems is unable to arrive at the reason. It is here that the safety man should step in and assist in the solution. He has specialized for years in finding such answers and it is under such conditions that he can be of maximum assistance to the men who are on the first line of attack. It is the solution of such problems that is one of the main purposes of this section. Again, there is still much to be done in improving the mechanical devices of safety. Electric signal systems are in the majority of cases not "fool-proof," yet most of them could be made so with just a little greater co-operation on the part of the safety and electrical engineers of our plants. Gear guards are far from perfect. Usually they are so constructed as to greatly interfere with the inspection of the gears they protect, hence inspections are less frequent, less thorough, and while we decrease the hazard to the men who grease and inspect the gears, we may increase that of those whose security depends upon the safety and reliability of the protected equipment, and who the law

*Discussion in connection with paper presented at 20th Annual Convention.

†Pres., A. I. & S. E. E., Elec. Supt., Carnegie Steel Co., Duquesne, Pa.

of common average indicates are far more likely to be injured than those such devices protect. I have merely cited two of the main problems of the work still to be accomplished by complete organized co-operation on the part of the electrical, mechanical, and safety engineers of our great industry. I have heard it said that when the organizers of accident prevention tackled the job, the thought that they would ever reduce accidents to the present state was remote. These present accomplishments were considered almost impossible. As each step and each milestone of progress has been made, they have set their goal higher. Now it is safer to work in many of our great industrial plants than to stay at home, and the time is not far distant, in the eyes of those who are optimistic, when years will pass in the large steel plants without anyone being seriously injured. It is my belief that this movement of this Association offers a great opportunity for service in hastening the arrival of this opportune time in two ways; first, interesting the safety men in our problems; second, securing greater interest on the part of our members in matters of safety. The effort which will be made will be worth while, even if it is successful in saving but a single life. It is my hope that its accomplishments will account for much more. And, therefore, I commend to you the taking of an active part in the work of this section during the coming year I feel that each of you can secure very direct benefit, not only for yourselves, but for those men back home who are working for you and for whose welfare you are responsible. You will be doing a service for your Company, to the community in which you live, and to those potential orphans and dependent children whose welfare is continually menaced so long as we do not do everything possible to promote safety in our daily occupation.

H. A. Renninger*: I count it a distinct honor to have the privilege of bringing to this meeting today, the greetings and good wishes of the Officers and Executive Committeemen of the National Safety Council.

The National Safety Council looks upon the Association of Iron and Steel Electrical Engineers as the God-Father of the Safety movement in America —for, as you will remember—it was by the members of your own group and at your 1912 Convention that a nucleus of safety leaders first conceived the idea of organizing a National Association to study the National accident prevention problem and establish a Clearing House of Information for Safety in the workshop, on public highways and in our homes.

It must be a source of great pride to you members of the Association of Iron and Steel Electrical Engineers to observe the growth of your God-Son: the National Association, that has developed from a group of 40 pioneers in 1912, to an Association of National and International importance in 1925.

The National Safety Council now includes in its memberships, 4,028 industries, railroads, associations, industrial boards, schools, colleges and other organizations—(400 of these members reside in 22 foreign countries)—representing 8,000 work shops and over 6,000,000 workers.

The great work of the Council is carried on by 1,000 voluntary Committeemen and a paid staff of 57 persons.

From its founding up to the present time, the Council has spent over $2,000,000 on its activities and only 35 per cent of this amount has been paid for overhead, including rent and salaries.

The Officers, Directors and Executive Committeemen contribute their time gratuitously to the direction of the activities of our 25 Sections for Industrial Groups, the 62 Community Safety Councils and numerous Research Committees.

These men, some of whom are in this room, deserve the gratefulness of their countrymen for their leadership—and to them belongs the credit for the development of the National Safety Council as a Clearing House for safety ideas and information.

A definite safety service has been built up on a truly co-operative basis.

Since 1913 they have prepared and sent out 4,886 different varieties of two colored posters.

In 1924 8,000,000 copies of 500 varieties of posters have been distributed. The National Safety News (with which a great many of you are familiar) is the premier magazine in its field.

The proceedings of the National Safety Congress make a volume of more than 1,200 pages; this volume containing the latest and best information contributed by the three to four thousand delegates attending the Congress.

To date, 75 Safe Practices Pamphlets have been issued, covering a great variety of subjects; this particular service is most valuable and every Safety Engineer and Superintendent should have a complete set of Safe Practices in his library.

The 1924 Safety Calendar, of which over one-half million copies were issued, finds its way into the home of the American worker.

There are many other services that the Council renders, not only to its membership, but to the country at large.

The gathering of statistics, compilation and study of the same and sending the results out broadcast, has helped many an organization to realize that more attention should be paid to safety and that many a leak and wastage should, and could, be stopped.

In addition to these noteworthy accomplishments, in which you, or the Association of Iron and Steel Electrical Engineers have taken so important a part, the National Safety Council has constantly been in contact with other national organizations, whose activities might relate in any way to the many-sided problem of accident prevention.

The Metal Section of the National Safety Council is one of the largest and strongest industrial sections of the council and they have covered a great field, but I realize that the Steel Industry is so vast —with other sides which perhaps they have not been able to cover—and I am referring particularly to the electric problem, which is now of the most important we have at present.

Practically all of the new plants and many of the old are becoming electrified, and it is the case of readjusting and educating the men to the hazards of electrical equipment—and there, I think, is the field for you men to study.

The Electrical Engineer has his particular problems, while the Safety Engineer has his; they cover

*Vice President National Safety Council.

a wide field and they must work hand-in-hand and through daily contact and conference must co-operate with each other in the fullest sense of the word.

I believe the Safety Section of the Iron and Steel Electrical Engineers can do a big piece of work and I feel that the organization which you expect to form today will work in conjunction with the Metal Section of the National Safety Council.

I want you to feel that the National Safety Council is always ready and willing to help you in any way they possibly can. As I have mentioned several times, they are a Clearing House for all subjects on safety. Their library is the most complete of any in the world, and the services of their staff are always available to any member.

No industry or organization in existence today, should go long without being a member of the National Safety Council. To those of you who are present today, Safety Engineers, Electrical Engineers and others—I would say, if you or your company are not members of the National Safety Council—I believe it would pay you well to become members and receive the many services of the Council.

The Safety movement touches every phase of human activity and many National Associations occupy honorable positions of accomplishment on safety, and I might mention in passing the following: The American Gas Association; American Society of Mechanical Engineers, and the other three founder Societies; The National Electric Light Association; American Railway Association; American Electric Railway Association; U. S. Chamber of Commerce; Mid-Continental Gas and Oil Association; Portland Cement Association. There are also a number of others.

These National Associations have safety sections such as you propose to organize today, and they have done exceptionally good work in Accident Prevention.

I might mention my own industry, The Portland Cement Association, which is most active in safety work, under the direction of Mr. H. C Jacobson, manager of the Bureau of Accident Prevention and the committee of the Portland Cement Association. Mr. Jacobson's services are invaluable, and his department is doing great work. Under his direction a National June Safety Campaign was held in the Cement Industry and of the 125 plants which took part, 72 went through the month of June without any lost time accidents.

The Safety Section of the American Railway Association has developed the nationally recognized "Careful Crossing" campaign, with which you are all familiar.

The American Electric Railway Association, through its Safety Committee, has done unusually good work in the collection, compilation and analyses of the records of accidents, involving electric railway equipment.

The American Gas Association is developing a Speakers' Bureau, through which their members are preparing themselves to deliver addresses on various phases of accident prevention.

The National Electric Light Association is emphasizing the development of giving publicity to an authoritative and scientific method of resuscitation from electric shock, drowning and gas asphyxiation.

Mentioning a few of the safety activities of other organizations, might help you in the formation of a program of activities for the proposed Safety Section of Your Association. Your leaders will know by experience the character of the activities that properly belong to your proposed Safety Section. It probably will mean the gathering together of the Safety and Electrical Engineers, so that the Safety Engineers may present their problems to the Electrical Engineers for solution, and the Electrical Engineers may become acquainted with some of the fundamental features of Safety Engineering, in order that their solutions may not omit any important features.

I take for granted that this committee will probably spend most of their time in the discussion of Accident Prevention to power house employes, boiler house employes, and to the design, installation and maintenance of gear guards, crane run-ways, etc.

In talking this matter over with the various members of the Executive Committee of the National Safety Council, we feel that working along these lines will be most helpful to your industry as well as industry as a whole.

I believe your work will be most valuable, and the results you obtain (the actual facts) should be known by the Executives of your Industry.

A small percentage of the Iron and Steel plants have made Safety paramount and an integral part of plant operation.

There can be no doubt, however, that the possibilities for economies and efficiencies from accident prevention are appealing more and more to the industrial managers, the workers and the public generally.

The possibilities are evident—with a continuation of the leadership and enthusiastic support demonstrated here today—there can be no doubt of the ultimate success of any program you may undertake

In closing, let me assure you once again that the National Safety Council offers to you its experience and facilities in any special activities you may undertake in the Safety field.

All of your undertaking will have our hearty support and we will hope for the continuance of the friendship and good-will given us at your annual conference in 1912.

C. B. Auel*: I came here today with little idea of forming other than a background, and certainly with no thought of being invited to the front and then told to "stand and deliver." I wish that I could rise to the occasion as did a friend of mine when unexpectedly called upon to speak, and who said: "Gentlemen, on the very threshold of my address I desire to thank you for this opportunity of speaking. And, in concluding my remarks I again wish to thank you for your kind attention."

But you want something a little more than this, and so I want to give you what may, perhaps, be a new thought on this safety work; at least, it came to me only within the past year.

Did it ever occur to you that every step by which civilization has advanced has been due to the inspiration of some individual, either man or woman? So that, a life snuffed out by accident may actually retard the world for untold ages. Take as an example, George Westinghouse, the founder of the Westinghouse interests, and the inventor of the air-

*President National Safety Council.

brake, the greatest safety device in the world today—for, if any of you were asked to name another like it, you would be utterly unable to do so. Not only is it the greatest safety device in the world today, but it is one of the greatest civilizing influences the world has ever had, for by means of it trains are enabled to be run at speeds which could not otherwise be maintained, thus bringing communities, states and nations into far closer touch with one another than would be possible without it. How much have living expenses been affected by the fact that trains can now be operated at forty, fifty and sixty miles an hour, instead of say, twenty miles? No one can say. But undoubtedly many of the world's commodities the poorer among us would have to do without.

Take another example. It was a woman who really gave to the McCormicks the idea of the mowing machine. After father and son had both failed in their efforts, she took a number of pairs of scissors, which she tied—or rather nailed— at right angles to a board, the same leg of each pair of scissors being nailed to the board; next she took a string, which she tied to the other leg of the scissors. Then when she pulled the string in one direction the scissors opened, and when she pulled the string the other way the scissors closed. And in this way the McCormicks, according to their own story, obtained their idea of the mowing machine.

Since something has already been said about the ladies, let me continue. It was a woman who was really at the bottom of our present-day pencil having a rubber on the end of it. It was a woman who discovered the flotation process of separating gold from dross. And I am further told that Mr. Carnegie has credited a woman with being the inventor of the present day steel mill rolls.

And, lest a lone lady here becomes unduly puffed up, I might add that it was a man, whose wife became a Suffragette, and who was left to take care of the baby—it was this man who went on a tour of investigation to discover the cause of the baby's crying, and when he discovered it he invented the safety pin.

But suppose the lives of these benefactors of mankind had been snuffed out by accident before they had had opportunities to give their ideas to the world! Would any of you say that had they not done so, someone else would have come along and done it? How do you know? Have you ever heard of "The Lost Arts?" Do you know what is meant by the term?

The term really refers to three arts of the ancients, which have become lost to present day civilization, only one of which has as yet been rediscovered; and without going into the details, I may state that one of these was the art of making the royal purple cloth worn only by the emperors and kings of the olden times, and which cloth was worth its weight in gold. That is the only one of these three processes that has been re-discovered.

The second was the making of steel blades of temper so fine and edge so sharp that a veil as light as the lightest of tissue paper, simply coming to rest on the edge, would be cut in twain. And that process has not yet been re-discovered.

And the third was the making of malleable glass, a glass that could be thrown about, and while being dented would not be broken. And because we haven't been able to find any examples of these, we, in our sublime conceit, are actually commencing to feel they never existed.

But I can tell you of others that have been lost and not found. Thomas Wedgewood, a few hundred years ago, saw in Italy a vase with beautiful raised figures upon it. It contained the ashes of Alexander the Great, which probably was the reason for its preservation. How its figures were put was a mystery, but Wedgewood, being a potter, persevered until he discovered it; and, as a result, we have the wonderful Wedgewood vases and pottery of today.

And I can tell you of other arts which have been lost and not yet found. Just how did the Egyptians erect their Pyramids and the Romans construct their roads; and of what material was the mirror in the Lighthouse of Pharos made, by which they could see the enemy ships at a great distance?

And no doubt there have been other arts lost to civilization and we never heard of them. And the world is the poorer. So you see, there is a very great possibility of an art once becoming lost and never being found again. And is it not reasonable to assume that among those whose lives are being snuffed out today before they have had an opportunity to run their natural course, there are many who would have contributed to the world's advancement?

In closing, I want to say, that I consider it the greatest privilege of my life to be associated with men such as you in this Safety Work; not alone in preventing and reducing human suffering, but in advancing civilization to an extent we simply cannot conceive.

Walter Greenwood*: The paper delivered by my comrade in warfare has stressed in plain language the importance of co-operation in bringing about results. We have been associated in the holy cause of safety for a good many years and never have we had a serious difference of opinion in regard to the methods. He has presented his subject in a way that leaves no misunderstanding in regard to his desires, which are the desires of all serious minded safety men, and he has laid before us, with comparatively few words, all that my efforts have tried to convey in the many years I have been associated with this organization. If the A. of I. & S. E. E. is to have a safety section, it should be congratulated on having associated with it such able and sincere men as we find in Mr. Oartel who, of course, expresses the sentiments borne by his chief, Mr. Burnett.

The importance of securing closer relation between those whose occupation is in line of providing greater security for life has, from the beginning of the activities of the A. of I. & S. E. E., been one of its chief considerations. There may have been a feeling in both organizations that the relations have not been as close as they should be. The fault, if fault it may be called, may not lie so much in lack of desire to co-operate as in misunderstanding regarding the methods that should be employed for bringing it about. Speaking of safety men in general, it may be that the safety man assumes the electrical man is not as much enthused by safety agita-

*Safety Director, Carnegie Steel Co., Youngstown, Ohio.

tion as he should be, and it may be that the electrical man, speaking of electrical men in general, assumes his superior knowledge of the operations of the mysterious and invisible force he is dealing with cannot be understood by others than those who have studied its action and are trained for governing it. He rightly feels that compliance with certain fixed principles, to the very letter, will avoid accidents but if he does not, he should consider the fallibility of humans in regard to compliance with laws or rules.

It is not easy for anyone to learn and understand the definition of electrical terms and principles. Of those engaged in the various capacities in the movement for safety, there are but few who are suspected of having any knowledge or training that would qualify them for understanding many of the most serious hazards connected with the installation and operation of electrical equipment. As for example, definition of the term Ampere as the unit of electrical current, and equals a volume of a current produced by a pressure of one volt flowing through a conductor having a resistance of one ohm, is absolutely incomprehensible to the ordinary layman or those who are not familiar with the technique of electricity. The application of electricity to the operation of equipment, employed in the industries, is conducted by persons highly qualified by education and experience, and all persons employed in operation and maintenance of electrical equipment used for lighting and other purposes, if their work has any responsibility attached, must possess considerable knowledge that has been acquired by study and experience.

Rather naturally the electrical man does not seriously consider the suggestions made by the safety man. The safety man is looking at results and may suggest remedies that to him look feasible, but in many cases they are not. The impracticability of the suggestions might be pointed out, but for various reasons, while the electrical man knows a practical remedy, he is not always ready and willing to impart his knowledge to the safety man. Among the reasons are, added complications that seemingly increase responsibilities; cost that seemingly is not justified by the added security that will be obtained, and these may be required of him.

The percentage rating of accidents occasioned by operating electrical equipment, these include shocks and burns, is not as high as that occasioned by many operations where the use of current or electrically operated equipment was not the chief factor, but it is too high and, doubtless, the severity rating is not exceeded in the hazard of any other employment.

It is the spirit of co-operation that not only stimulates but produces effort that both safety and electrical men are after, and it is to be hoped that the formation of a safety section will strengthen such bonds as now exist. A closer relation between safety engineers and electrical men will enable the safety men to understand why supervisors of electrical work can be excused for not being able to prevent some mishaps and why they should not be excused for not preventing others. While, of course, the head of an electrical department is held responsible for all occurrences within his department, he cannot be able to prevent the failures of equipment operators who cannot be performing their work directly under the eyes of a supervisor. As an instance, an operator may be required to do some work on lines of high potential where the work cannot be done without opening a disconnecting switch, and he does this without first opening the safety switch in lead of the disconnector, the result being someone is injured seriously if not fatally. This operator knew how to safely operate the switches, his ability had been proven, but for an unexplainable reason he failed to do his work in the proper way. Again, relating to the same occurrence, the responsible head of the department may have failed to enforce a system whereby the qualifications of his subordinates would be proven before entrusting them with the responsibility of operating dangerous equipment, then if the operator ignorantly opened the disconnecting switch without first opening the protecting oil switch, the department head would be at fault.

The safety man cannot be unreasonably exacting. He must realize that in particular cases a distinction must be made between the requirements for securing safety, as to the relative practicability of adhering closely to literal requirements of the standards.

The electrical man cannot assume that because it is possible, by exercising caution, equipment can be operated safely, therefore he need not be scrupulously particular about adhering to literal requirements of standards.

To prevent accidents by making safer installations within the electrical departments of the iron and steel industries may require larger money outlay than is required in the converting and rolling departments, yet however much the aggregate cost may be, we know the expenditure is justified by the financial saving effected. The cost of making railway travel safe was justified by results and, too, the time will come when it will be said the cost of providing the highest possible degree of safety in crossing railroads has been justified by results.

These remarks have not been uttered with intent to make more comprehensive what has been said by Mr. Oartel, but they are meant to be a testimony to the sincerity of those who are devoting their energies to one of the most holy causes men are engaged in.

J. S. Murray*: Our Plant Safety Committee consists of five members and three ex-officio members as follows:

Chief Electrician, Chairman.
State Compensation and Hospital Clerk, Secretary.
Master Mechanic, Member.
Shear Floor Foreman, Member.
Labor Foreman, Member.
General Manager, Ex-officio Member.
Mill Superintendent, Ex-officio Member.
Night Superintendent, Ex-officio Member.

We also have a Fire Department that comes under the safety organization and is as follows:

Pipe Fitter Foreman, Fire Chief.
Assistant Master Mechanic, Assistant Fire Chief.
Night Mill Superintendent, Assistant Fire Chief.

We also have two Investigating Committees consisting of three men on day turn and three men on night turn selected from department foremen and

*Electric Supt., Follansbee Co., Follansbee, W. Va.

members of which are changed every two months one at a time.

We also have a First Aid Team with Captain with members picked from the ranks. Both of the above committees come directly under the Safety Committee.

The Safety Committee meets every two weeks without fail and usually invites the Fire Chief or his assistant, Captain of the First Aid Team, Chairman of the Investigating Committee, the General Manager or Superintendent to attend each meeting. Minutes are kept of each meeting. All safety matters brought before the committee are numbered and carried through until completed. All unsafe conditions throughout the plant are thoroughly discussed, including fire hazards and lost time accident reports which have been previously turned over to the Secretary and Hospital Staff by the Investigating Committee and Fire Department.

The Fire Marshal makes a monthly report pertaining to the condition of fire equipment which is distributed throughout the plant with any suggestions necessary, which are carried out by the Safety Department. The Chief of Police is responsible for the condition of stretchers and bulletin boards with bulletins which are distributed throughout the plant and he also makes his report as to the condition of same once every three months to the Safety Committee.

The company also maintains an inhalator in the Electric Sub-Station for rescue work and is operated by sub-station operators who are on duty at all times and are properly trained in its use.

A suitable whistle code is provided for fire alarm in each department so that all that is necessary is to call the telephone operator in case a fire is discovered by any one in the plant. The operator will in turn notify the Power Station by telephone, giving the proper code.

All employes are hired by department heads and are usually advised as to the safety first movement and particular hazards pertaining to the department in which they seek employment.

The Safety Department is now considering the organization of Sub-Safety Committees in each department and the management is considering adopting physical examination for all employees.

The company also maintains a plant hospital with trained nurses employed on all turns, but do not employ a surgeon continuously, rather they call him when needed, while he usually makes a schedule trip to the plant hospital at noon of each day.

There are 1,500 men employed and very few lost time accidents in the last five years.

W. S. Hall*: I was very much impressed with one statement made by Mr. Burnett in the early part of his remarks, and that is the question of education. I believe it is a well established fact, a fact with which most of you safety men are already familiar that something close to 90 per cent of the accidents which now occur are the fault of the workmen themselves. The various companies have spent hundreds of thousands of dollars for devices with which to make equipment safe. In most cases these expenditures have been very much worth while, and no doubt the accident rate has been cut down, due to these expenditures, however, it is felt that most plants have nearly reached the maximum in accident prevention by this means, the remaining accidents being caused by thoughtlessness on the part of someone. The question of educating men to think should, I believe, be adopted as a slogan for the safety work of this association. This association has the reputation of accomplishing results and, therefore, if we are to maintain this reputation, as far as the safety work is concerned, it is necessary that we outline some definite procedure and work along that line the coming year. It is, therefore, my suggestion that our efforts be spent in devising definite educational campaigns to teach men to use their eyes, their ears and their brains. When this is accomplished, and of course, this goal will never be reached 100 per cent, the need for additional safety devices, and in fact, the need for many devices already installed, will entirely disappear."

I believe the foregoing is about what I intended to say, however, more can be said if more discussion is desired.

R. G. Adair*: I don't think that I could add to this splendid program, unless I might appoint myself spokesman for the group of safety engineers present here today.

As I have been under the impression that some such movement as this would take place in your association, I have discussed the matter with a number of safety engineers and am convinced that all of them welcome the opportunity to sit with this association.

Those of us who devote our entire effort to the prevention of accident realize the magnitude of the job as it is effected by the present day lay out of electrical equipment in the modern steel plant. And for the most part, we safety engineers need the close co-operation and assistance of the electrical engineers as we are not technically trained along this line. By being permitted to attend your technical sessions, your electrical exhibits, and to become better acquainted with each one of you, we safety men will reap the reward of a better electrical education and may in turn be able to more definitely direct your attention to the safety requirements of the work for which you are responsible.

It seems to me that this association also affords another distinct advantage to the safety engineer group in that those of us in the same industry with similar problems will become better acquainted than has been possible heretofore, and will therefore have a better opportunity to discuss among ourselves effective ways and means of serving our industry in our particular line of endeavor.

*Elec. Engr., Illinois Steel Co., So. Chicago, Ill.

TWENTIETH ANNUAL CONVENTION, SEPTEMBER 14th TO 19th, 1925

Attendance

The Twentieth Annual Convention was probably the best attended so far as engineers from the Steel Industry is concerned in the history of this Society, exceeding all expectations.

Sessions

Monday, September 14th

Over 200 engineers from all parts of the United States, including some of the most prominent Safety

*Safety Director, American Rolling Mill Co., Middletown, Ohio.

Engineers in the United States, attended the opening session, which was devoted to the subject of "Safety." Mr. L. H. Burnett, Assistant to President, Carnegie Steel Co., acted as Chairman, and under his able management this session was one of the most successful ever held by this Society. Mr. John Oartel, Chief Safety Director, Carnegie Steel Co., presented a paper covering the subject of "How the Electrical Engineer and the Safety Director can be Mutually Helpful." This paper was discussed by Messrs. C. L. Baker, Management's representative, Bethlehem Steel Co., Johnstown, Pa.; C. B. Auel, President, National Safety Council; Henry A. Renninger, Vice President National Safety Council; W. S. Hall, Elec. Engr., Illinois Steel Co.; Walter Greenwood, Safety Director, Carnegie Steel Co., Youngstown, Ohio; R. G. Adair, Safety Director, American Rolling Mill Co. The discussion indicated that notwithstanding the fact that millions and millions of dollars, which have been spent in safety devices and safety appliances to make equipment safe, accidents were still occurring, at a very much less rate of course, but the fact remained that there was still work to do and that much could be accomplished with a definite plan of education for the workman.

Tuesday, September 15th

Preceding the regular technical session Tuesday morning the Annual Business Session was held. Reports were presented by the various committees, covering their work during the year. All of the reports indicate that 1925 was one of the most prosperous years that the Association has ever enjoyed. The election of officers resulted as follows:

For President, Geo. H. Schaeffer, Elec. Engr., The Carpenter Steel Co., Reading, Pa.

For First Vice President, S. S. Wales, Elec. Engr., Carnegie Steel Co., Pittsburgh, Pa.

For Second Vice President, A J. Standing, Elec. Supt., Bethlehem Steel Co., Bethlehem, Pa.

For Treasurer, James Farrington, Elec. Supt., Wheeling Steel Corp., Steubenville, Ohio.

For Secretary, F. W. Cramer, Elec. Engr., Bethlehem Steel Co., Johnstown, Pa.

Directors

F. G. Cutler, Chief Bureau of Steam Engrg., Tennessee Coal Iron and R. R. Co., Ensley, Ala.

Walter H. Burr, Elec Eng., Lukens Steel Co., Coatesville, Pa.

R. S. Sawdey, Elec. Engr., Van Dorn Iron Works, Cleveland, Ohio.

W. P. Chandler, Spec. Engr., Carnegie Steel Co., Pittsburgh, Pa.

R. L. McIntosh, Elec. Engr., Inland Steel Co., Indiana Harbor, Ind.

At a meeting of the Board of Directors, held previous to the Tuesday Business Session, it was decided to hold the Twenty-First Annual Convention and Exposition in the City of Chicago, at the Sherman Hotel, the first week in June, 1926. Some criticism has been offered by the Steel Companies at holding our Conventions in September, due to the fact that practically all of the Engineers and Superintendents have just returned from their annual vacations, making it very difficult for these Executives to again absent themselves after such a short return from vacations. Also, a large number of Societies hold their Conventions in September. Therefore, the Board of Directors felt that the month of June would be the most suitable, due to the fact that very few Conventions are held in June, and the vacation season has not yet begun. The Board of Directors also decided that wherever it was possible that the Convention and Exposition would be held in Hotels and not in auditoriums.

After the Business Session Mr. Geo. H. Burnham of the Engrg. Dept. Condit Elec. Mfg. Co., Boston, Mass., presented a paper covering the subject of "The Selection and Maintenance of Oil Circuit Breakers," which was followed by a paper covering the same subject by Mr. M. J. Wogelmuth and E. K. Reed of the Westinghouse Elec. & Mfg. Co., at East Pittsburgh, Pa. These papers were discussed by Mr. D M. Petty, Mr. A. C. Cummins, Mr. Geo. Schaeffer, Mr. James Farrington, and Mr. E. C. Stone. One of the questions that was raised was in the designing and reconstructing of the present power system in the steel industry, the amount of investment required for Oil Circuit Breakers seemed to be rapidly mounting into figures which require serious consideration, especially in these days when electrifying the present steam driven plants. It was felt that if new designs could be submitted for Oil Breakers and Switch equipment, which would not require so much capital that complete steel electrification would be a much earlier possibility. Another question, which was brought up, was why a large tank with considerable oil is necessary to take up the heat of an arc whereas breaking it with a tetrachloride fuse is a comparatively simple matter and that fuse is supposed to break the arc without breaking the glass.

Wednesday, September 16th

Direct Current Armature Windings for Multi-Polar Generators and Motors, Frogleg Windings, by W. H. Powell and G. M. Albrecht, attracted the engineers from, not only the Steel Industry, but a large number of other industrials as well. The complete discussion covering this paper will appear in the November issue of the Iron and Steel Engineer. You will find it very interesting, as many points were brought up which are of utmost importance to the Electrical Superintendents and engineers of the Iron and Steel Industry.

Thursday, September 17th

The Electric Heat Committee, of which Mr. Geo. H. Schaeffer is Chairman, presented their report for the year which consisted of a number of papers, one by Mr. J A. Seede, Ind. Engr., General Electric Co., Schenectady, N. Y.; one by Mr. E. A. Hurme, Mgr. Steel Mill Div., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.; one by Ralph A. Butler, Efficiency Engr., Donner Steel Co., Buffalo, N. Y. All three of these papers were discussed at considerable length.

In connection with the Electric Heat Committee's report Mr. Frank Watson of the International Nickle Co., described their practices in Pouring Steel into the ingot mould. This practice is a novel and new one, and has aroused so much comment that it has been decided to have Mr Watson present a paper before the Pittsburgh District Section at the December Meeting The present practice at the International Nickle

Co., offers the Steel Industry a medium in which to reduce their costs and also improve the quality of their metal. The Electrically heated Soaking Pit also occupied a major portion of the attention of the steel Mill engineers. The complete discussion of the Electric Heating Committee report will appear in the November issue of the Iron and Steel Engineer.

Friday, September 18, 1925

Mr. A. L. Penniman, Jr., presented a paper "Auxiliaries and Auxiliary Drives for Steam Electric Generating Stations." The discussion of this paper was of such interest and length that it was necessary to stop the discussion in order to allow the balance of the program to be presented. This discussion will also appear in the November issue of the Iron and Steel Engineer.

Mr. Joseph G. Worker presented a paper "Extending the Heat Cycle in Boiler Rooms by the Use of Preheated Air for Combustion Purposes." This paper also proved very interesting. Mr. John VanBrunt, Vice President in Charge of Engrg. Combustion Engineering Corp. of New York, has offered a discussion which appears in the October issue under the editorial columns of the Iron and Steel Engineer.

Social Sessions

Monday Evening the Association of Iron and Steel Electrical Engineers entertained their members and guests at an informal gathering and dance at the Benjamin Franklin Hotel. This activity was under the auspices of the Philadelphia District Section It was attended by over 400 members and was voted one of the most enjoyable that the membership had ever been privileged to enjoy.

Thursday evening the members and guests attended a dinner dance given under the auspices of the Philadelphia District Section. The Dinner dance was a new innovation instituted by the Association and from the number of complimentary remarks this feature will be a permanent one with the A. I. & S. E. E. The entertainment provided during the evening was equal to that to be obtained at any of the largest theaters. Too much credit cannot be given the Philadelphia Section for their wonderful efforts in this connection.

Iron and Steel Exposition

In the preceding paragraphs, mention is made as to the attendance, technical and social sessions, as well as other events in connection with the convention.

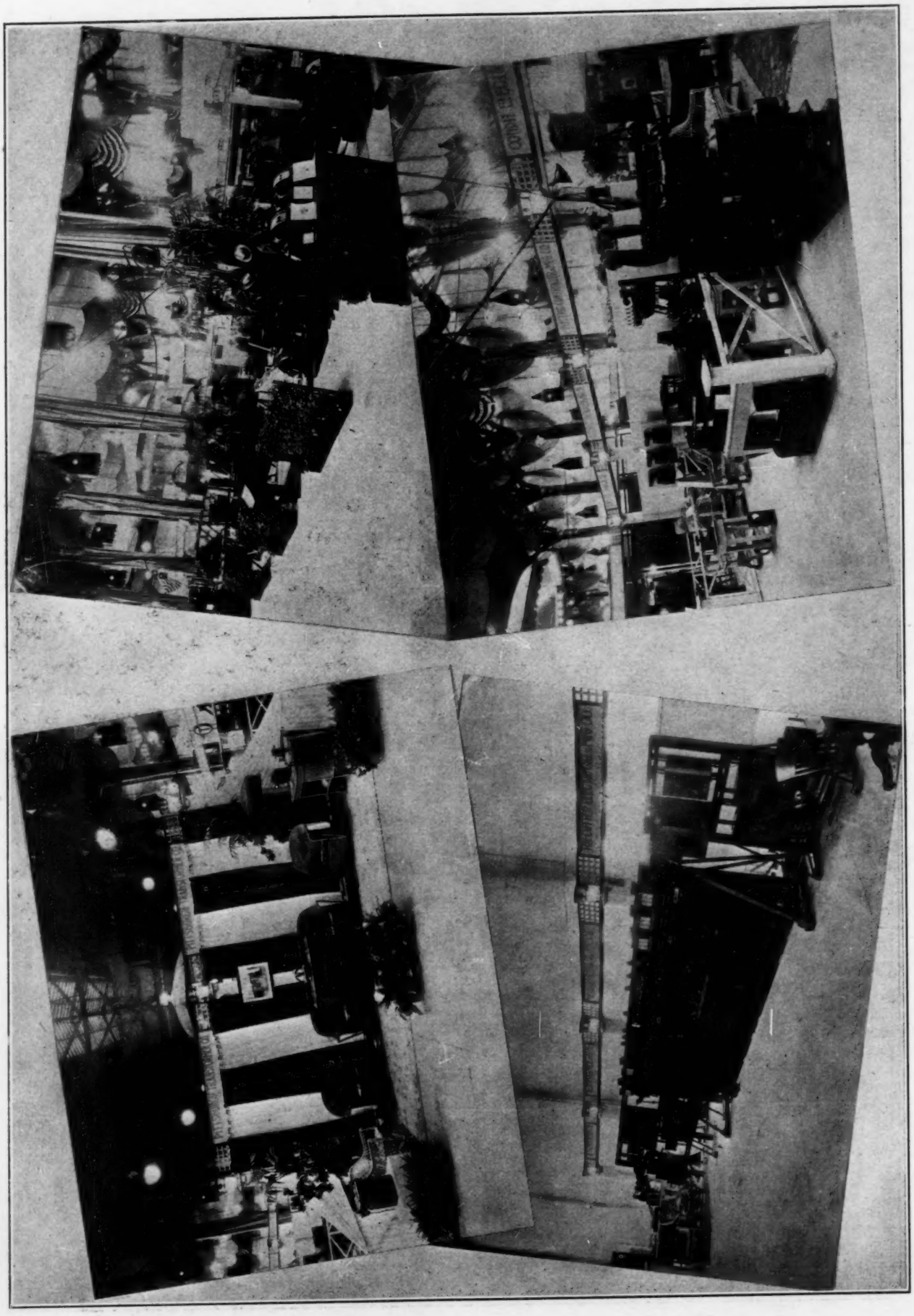
For those who were in attendance at the Exposition, we feel safe in saying that they witnessed what many engineers consider the best display of apparatus in the history of our shows.

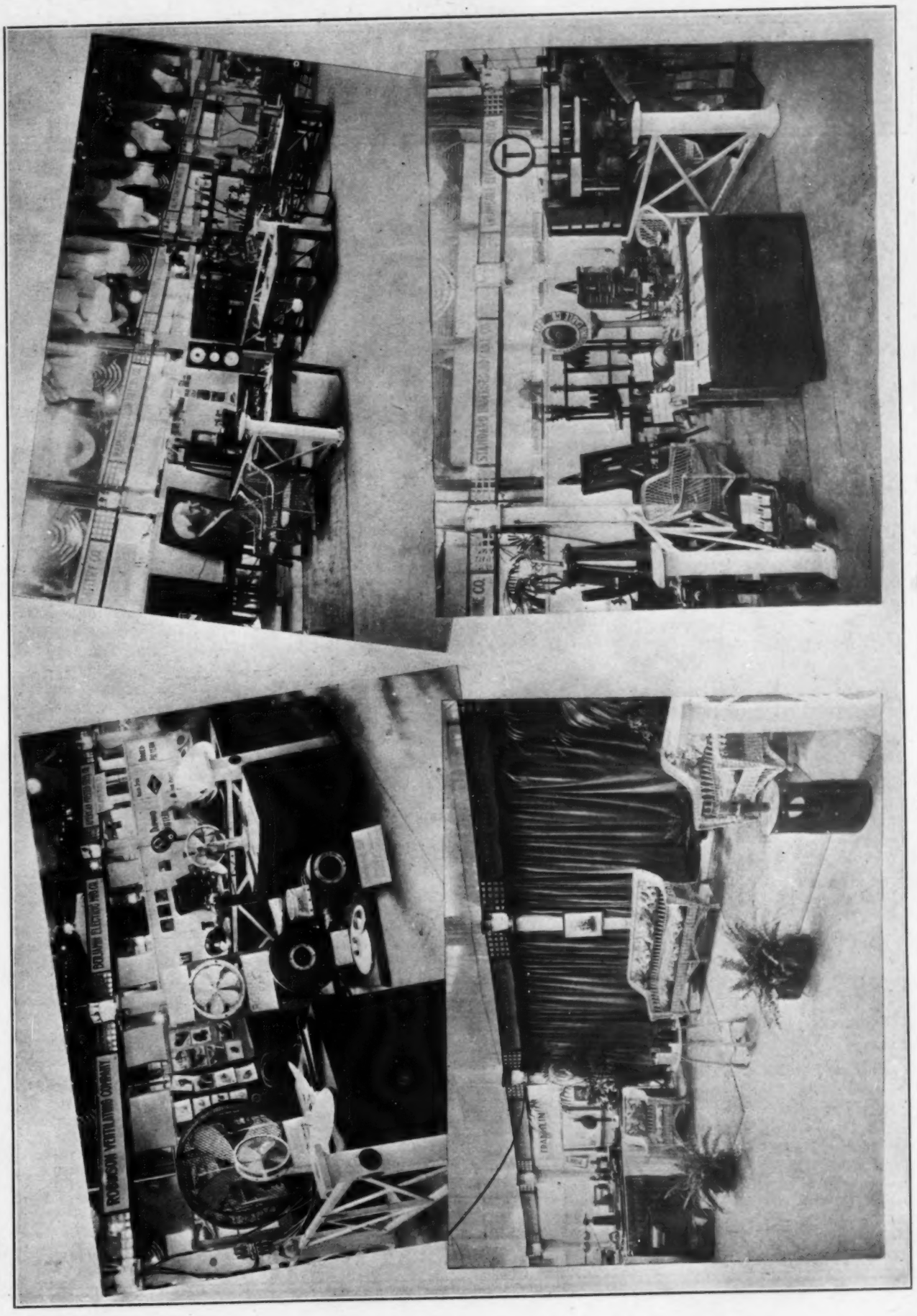
While it is a little early to say that every exhibitor has already been benefited by his display, it is gratifying to know that in less than one month more than half of the exhibitors have written in expressing their pleasure in having been present at this affair.

For those who were not present, we are listing below the companies who were represented so that an idea may had as to just what was shown at this exposition:

LIST OF EXHIBITORS

Ace Welding Machinery Company
Allis Chalmers Mfg. Company
Alliance Machine Company
American Electric Fusion Corporation
American Pressed Steel Company
The Andersen Company
Appleton Electric Company
Baker R & L Company
The Bartlett Hayward Company
Benjamin Electric Mfg. Company
Allen Bradley Company
Bussmann Manufacturing Company
Celite Products Company
Clark Controller Company
Cutler Hammer Mfg. Company
Calebaugh Self Lubricating Carbon Co.
Cutter Electrical & Mfg. Company
Craven Electric Sales Company
Crouse Hinds Company
Chicago Fuse Mfg. Company
Corliss Carbon Company
Condit Electrical Mfg. Company
Crocker Wheeler Company
Detrick Arch Company
John C. Dolph Company
Economy Electric Products Company
Electric Development & Machine Co.
Edison Storage Battery Company
Electric Storage Battery Company
Erie Malleable Iron Company
Electric Service Supplies Company
Electric Controller & Mfg. Company
Economy Fuse Mfg. Company
The Electric Journal
Fuels and Furnaces
Fuller Lehigh Company
General Furnace Company
General Electric Company
Gehnrich Industrial Heat Oven Co.
Hyatt Roller Bearing Company
Heppenstall Forge & Knife Company
Holophane Glass Company
Homestead Valve Manufacturing Co.
The Hayward Company
Johns Manville, Inc.
Keystone Lubricating Company
McGraw Hill Company
Marlin Rockwell Company
Morgan Engineering Company
Morganite Brush Company
Monitor Controller Company
Martindale Electric Company
Mutual Electric & Machine Company
Mutual Foundry & Machine Company
New Departure Mfg. Company
Norma Hoffman Bearings Corp.
National Carbon Company
National Electric Mfg. Company
Nichols Lintern Company
Ohio Electric & Controller Company
Otis Elevator Company
The Okonite Company
Pittsburgh Transformer Company
Pyle National Company
Philadelphia Grease Mfg. Company
Packard Electric Company
Riehle Brothers Testing Machine Co.
Robinson Ventilating Company
Rowan Controller Company
Roller Smith Company
Republic Flow Meters Company
Rollway Bearing Company
Reliance Electric & Engineering Co.
Shepard Electric Crane & Hoist Co.
Square D Company
Standard Underground Cable Co.
The Sharples Specialty Company
SKF Industries, Inc.
Stackpole Industries, Inc.
Schweitzer & Conrad
George Sachsenmaier Company
Trumbull Electric & Mfg. Company
Trumbull Vanderpoel Company
Tinius Olsen Testing Machine Co.
Thomas Flexible Coupling Company
Thompson Electric Company
Tool Steel Gear & Pinion Company
Harold E. Trent
United States Graphite Company
V. V. Fittings Company
Edward L. Weigand Company
Westinghouse Electric & Mfg. Co.
Weston Electric Instrument Company

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The Generation of Electrical Power, Using Waste Heat

By F. O. SCHNURE*

WHILE it is a matter of geographical record that Sparrows Point was established before Baltimore, it was not until 1886 that land was acquired and its history as a steel plant began. The plant consisted of four blast furnaces, originally planned to convert Cuban ore into pig iron, to be shipped to Steelton for further conversion into rails, was extended to include a Bessemer plant and rail mill. The first blast furnace went into operation on October 23, 1889, the others following at intervals, the fourth being completed on April 14, 1893. The Bessemer plant and rail mill were put into operation in August, 1891. The original units, with the addition of five open hearth furnaces in 1910, comprised the Maryland plant until 1917, which saw the beginning of the construction program that produced the plant as it is today. The plant was first operated entirely by steam and hydraulic gear, but the electric motor gradually superceded some of the steam and hydraulic auxiliaries, until in 1902 we have records showing a total consumption of 3,000,000 k.w.h per year.

Power in the early days was generated from blast furnace gas burned under low pressure boilers, coal being used for "standby" service. In 1913, when service was established from the Consolidated Gas, Electric Light and Power Company of Baltimore, the generating equipment consisted of four 250 k.w., 250 volt d.c. reciprocating units; one 750 k.w., 550 volt a.c. turbo-generator, and one 750 k.w., 250 volt d.c. turbo-generator. The power back of the plant therefore was 2,500 k.w. capacity produced from waste gases and 2,500 k.w. central station capacity, making a total of 5,000 k.w. The yearly consumption at that time was about 15,000,000 k.w.h.

Since this period, the consumption of power has followed the growth of the plant, until in 1923 records compiled by the Electrical World show that this plant consumed one-fourth of one per cent of all the power generated in the United States. The figures referred to being 70 billion k.w.h. for central stations and industrial establishments combined and 158 millions for this plant.

In 1924 the consumption of power in this plant was practically the same as in 1923, and as the generating facilities had been extended to utilize more of the waste fuel available, 146,500,000 k.w.h. was generated, 91%, or 133,300,000 being produced from blast furnace gas. The amount produced from "waste fuels" alone is one-fifth of one per cent of all the power generated in the United States; or 35% of all the power distributed by the Consolidated Gas, Electric Light and Power Company during 1924, for industrial and commercial use, excepting that power furnished this plant and the United Railways.

*Elec. Supt., Sparrows Point Plant, Bethlehem Steel Co., Sparrows Point, Md.

The total consumption of power at Sparrows Point was 29% of all the power distributed by the above company, for industrial, commercial and railway uses. These figures and comparisons are presented to show the vast quantity of energy now developed from one time "waste gases" of blast furnace operation. As previous papers have pointed out, the potential energy available from all waste sources is at present under developed.

The sources of electrical energy for the Sparrows Point mills are threefold:

1. A gas engine plant consisting of six 5,000 k v.a. gas engine-driven generators.
2. One 12,500 k.v.a. turbo-generator.
3. Central station circuits of 20,000 k.w. capacity.

The turbo-generator is a standard General Electric Co. three-bearing, 12,500 k.v.a. at 80% power factor, 250# 200° superheat unit. It is equipped with an Ingersoll-Rand single pass surface condenser, having 13,000 sq. ft. tube surface. Steam jet air pumps aroused and condensate is handled by

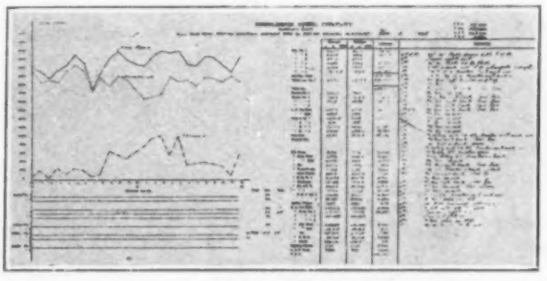

FIG. 1.

a motor-driven pump with a steam-driven unit, as an auxiliary. Cooling water is provided by passing through the condenser, practically all the water that is used for cooling purposes in all parts of the plant. This represents 40,000 cu. ft. of salt water per minute at 50# pressure. The loss in head in passing through the condenser is 3½# and the rise in temperature is about six degrees at full load, neither item affecting its usefulness as a cooling medium on the furnaces, open hearth and mills beyond.

The boiler plant used in connection with this turbine consists of two 1291 BHP Babcock & Wilcox boilers, equipped with automatic control for blast furnace gas operation. Fuel oil is used as an auxiliary, when blast furnace gas is not available.

Power is generated in the Sparrows Point station at 6600 volts, 3 phase, 25 cycles, and additional power is received from Baltimore at 26,000 volts. The latter is transformed to 6600 volts by three 7500 k.v.a. 3 phase transformers at the No. 1 substation and transmitted a third of a mile directly to the main power house bus. The operator in this

station, therefore, has centralized control of the distribution of all power. With the exception of the local or house bus load all power is distributed at 6600 volts over a double loop system.

Waste gases have to date been the means of generating a maximum of 30,000 k.w. per hour, which, combined with the central station circuit capacity of 20,000 k.w., makes a total maximum capacity of 50,000 k.w. Variables in the form of gas supply and engine operation place the normal maximum capacity of the system at 45,000 k.w. The normal load on the system under present operation is around 30,000 k.w. per hour during the day and 27,000 at night. The difference between day and night consumption is due to day operation of the rail mill, some of the shops, foundry and the shipyard. There is practically no difference in the power used by the mills during either day or night operation, as power consumption is directly proportional to the tonnages produced, and night tonnages are comparable to day tonnages.

During 1921, when only one furnace was in blast, the power produced, after providing gas for its own blowers, was 58,000,000 k.w.h. Monthly production for four months during the year averaged 5,450,000 k.w.h. At times, depending on the furnace operation, four gas electrics produced 14,000 k w.h. per hour.

Four main sub-stations served from switching towers distribute the power to the various mills. A 30,000 k.w. load is absorbed, according to the following schedule, showing the average hourly load, the maximum demand and the average k.w.h. required per gross ton of product.

In March a total of 18,000,000 k.w.h. was consumed, which is from 80 to 90% of the industrial and commercial power used by all other industries served by the power company in Baltimore and vicinity during the same period. Seventy per cent of this power was produced from blast furnace gas, sixteen per cent from auxiliary fuels and fourteen per cent was purchased.

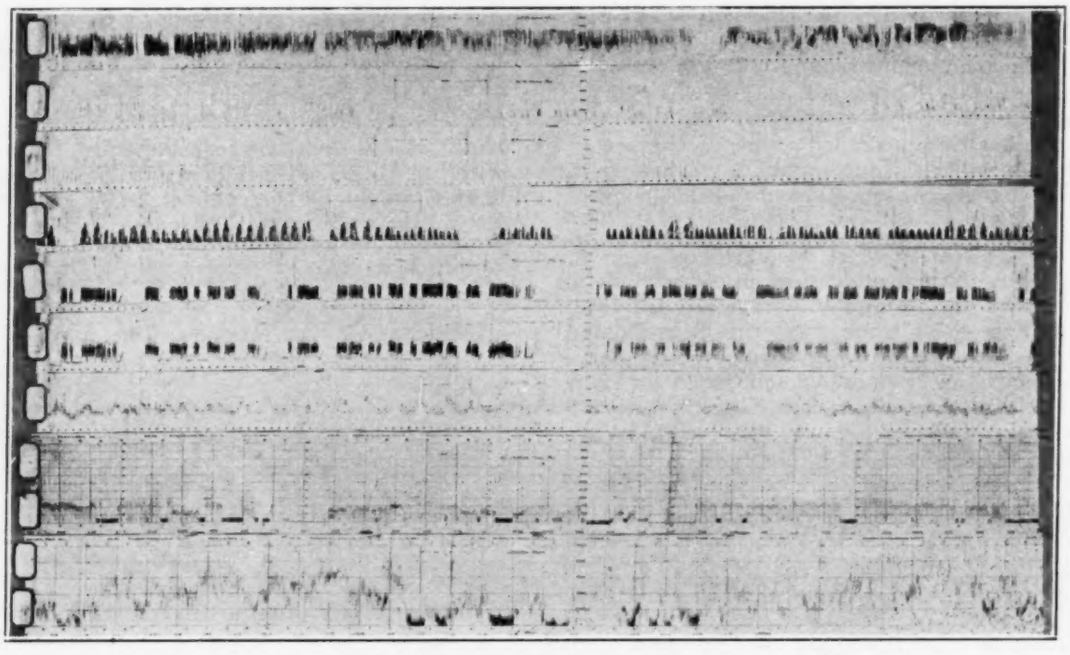

FIG. 2.

The curves shown in Fig. I, being a reproduction of our power house log sheet for March 3, 1925, show the character of the hourly load, as well as the amount generated and purchased.

All the power is consumed by motors, there being no electric furnace or large heating load. These motors number in excess of 2,500, 30 being in a class over 500 H.P. and under 5,000 H.P. The connected load in auxiliary motors, including both a.c. and d.c. is 75,000 H.P. and in main motors 50,000 H.P., making a total of 125,000 H.P.

The combined effect of all these large motors with their intermittent loads, produces a load curve that at times shows 10,000 k.w to 15,000 k.w. fluctuation in one to three-minute periods. Figure 2 shows curves representing the power input into the various main motors and also that representing the purchased power.

Department	Hourly Consumption	Max. Hourly Demand	K.W.H. Ton
Central Pumping Station	2500	2500	
Coke Ovens	2500	2750	23.5
Blast Furnaces	800	1250	8.8
Open Hearth	1200	1500	12.5
40″ B. Mill, 24″ Cont. Mill, 18″ Cont. Mill	7200	11000	60.0
26″ Rail Mill	2000	5000	48.0
60″ Plate Mill	2000	4000	90.0
110″ Plate Mill	1800	5000	80.0
Tin Plate Mill	5500	6000	250.0
Sheet & Jobbing Mill	3000	3500	147.0
Shops and Miscellaneous	1000	1500	
Shipyard	500	1000	
Plant total	30000	45000	44.5
Units Under Construction			
40″ x 90″ Blooming Mill		4000	5000
Wire Rod Mill		4000	5000
Total as of 1926		38000	55000

Steel Treating and Its Value to the Steel Engineer

By R. F. CRUMP*

A. Brief outline of the development of machinery parts to keep up with demands of engineers for better material, based on demands due to availability of greater power.
   1. The wooden gear wheel.
   2. The cast iron gear.
   3. The cast steel gear.
   4. Alloy and special steels.

B. Methods and materials in use to give more effective results in the wearing problems encountered in the steel industry.
   1. Heat treatment of carbon and carbon-alloy steels.
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      (b) The Allotropic theory.
      (c) Limitations of parts thus made.
      (d) Relative costs and wearing life.
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      (c) Relative costs and wearing life.
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         (1) General character and analyses.
         (2) Advantages for certain types of work.
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         (1) General character and analyses.
         (2) Advantages for certain classes of of work.
         (3) Factors limiting its use.

C. Stroh Steel.
   1. Statement of its nature and its physical properties.
   2. General advantages of Stroh Steel viz. wearing life, resistance to shock, etc., etc.
   3. Its use in steel plant wearing problems—
      (a) Gears and Pinions.
      (b) Mill Pinions.
      (c) Spindles and boxes.
      (d) Shear Blades, Guides, etc.
      (e) Crusher parts.
      (f) Crane Wheels.
         (1) Method of manufacture (hammering).
         (2) Advantages vs. rolled and cast and alloy wheels.

D. Definite application of special alloy to the steel industry, with comparative costs and wearing life.
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      (b) Sintering machine pinions.
      (c) Sintering machine paddles.
      (d) Wheels for Pig Casting machine.
      (e) Elevator Gears.
      (f) Sheaves.
   2. Open Hearth—
      (a) Pusher Pinions.
      (b) Charging Peels.
      (c) Lorry Car Wheels.
   3. Rolling Mills—
      (a) Spindles; boxes and couplings.
      (b) Mill Pinions and types.
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      (a) Gears and pinions.
      (b) Sprockets.
      (c) Sheaves.
      (d) Chains.

E. Conclusion.
   1. Outline of general conclusions.

The development of present day machinery in the steel plant has been made possible primarily by the invention and use of the mechanical principle of the wheel. The origin of its invention is lost in the haze of prehistoric times. As early as 450 B. C., we have mention of the use of the water wheel, and, by inference, the use of the gear, i. e., the pin wheel and cage. From the inception of the first use of the wheel for purposes other than transportation, the progress of mechanical development is more clearly defined.

The development of the gear wheel opened a new era. About 600 A. D., some genius developed the wooden gear, making practical crude wind mills and flour mills run by water. After this date the development of the wooden gear, both as to accuracy of workmanship and design, and in size and strength, permitted a more rapid increase in size, variety and flexibility of machinery and its consequent developments.

About 1700, the size of machinery had increased to the point where the strength of the wooden gear

*M. E., Stroh Steel Hardening Process Co., Pittsburgh, Pa.

was no longer adequate and the iron gear came into use. This marked another great era in the development of mechanical appliances. As early as 1740, rolling and slitting mills came into existence. There seems to have been no limit at this time to the possibilities of machinery, except the natural limitation of power available. The iron gear wheel could withstand any stress applied and machinery had reached the maximum size for which power could be furnished about 1750.

In 1769, James Watt patented the first steam engine. This permitted of the furnishing of power at places heretofore impossible and rapidly developed to such an extent, that mechanics were no longer limited by the amount of power obtainable. In 1784 the first steam flour mill was erected and in 1840 iron rollers were developed, which could withstand the stress of rapid feeding and which again called for the application of greater power. But the iron gear wheel was still competent to withstand the additional stress applied and the natural demand of the engineer was for greater power rather than greater strength of material. In fact there was no practical limit to the size of machinery until the

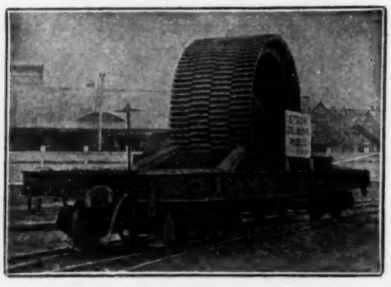

FIG. 1.

latter part of the nineteenth century, when steam and electric units had been developed to a point where the power obtainable at any given place was purely a matter of choice.

About 1883, the demand of the designer and engineer for stronger, more wear resistant material for the transmission of power became insistent and the cast steel gear wheel came into its first service. This seemed to be the ideal metal, having a tensile strength of 70,000 pounds per square inch, with all mild steel's ductility, toughness and resistance to shock. Heavier rolling mill equipment became the rule. Sky-scraper buildings became possible by the fact that heavy sections could be rolled. Much larger cars and locomotives were possible on account of the fact that heavier plate and heavier rails were obtainable. Again, however, as the machines grew larger, it was discovered that this remarkable gear of cast steel had its weakness as well as its strength, and that it could not withstand abrasion under the enormous pressures made possible by its tensile strength and elastic limit. High carbon steels were cast, and while the resistance to abrasion was greatly increased, with the resistance to abrasion came a great loss in toughness. The now conscious demand of the designer and engineer for strength more resistant material became insistent. In first response to this demand, Sir Thomas Hadfield of England, placed on the market the first of the alloys suitable for castings—Manganese Steel. It had great resistance to abrasion and wear, and, **when properly heat treated** was tough, but was difficult to machine, and the great majority of parts need some machine work. Also the elastic limit was very low, bringing with it danger of flowing or smearing and of bending in service.

Again at this time, the heavier and stronger machine tools, which were expected to do much work, were found to be too severe on the cutting tools and a flood of special purpose alloys—hard steels, tough steels and high speed steels—were thrown on the market. Cobalt, Tungsten and even Iridium steel for the machine tool; Nickel Vanadium and Titanium steel for manufacturing tough material; Manganese, Chrome and Nickel Chrome steels for resistance to wear. This was probably the beginning of the real and conscious activity of the metallurgist in the endeavor to solve mechanical problems through the creation of special metals.

With the development of metals and design of machines, came also the advent of the efficiency engineer, who considered first cost, operating cost, repair cost (and all the other items heretofore considered separately), as merely factors in one problem, and the demand of the efficiency engineer was not satisfied by any of the metals in existence. The merit of each was beyond denial, but unfortunately with these unquestioned merits came cases proving weaknesses.

His demand became definite and insistent. Best strength of steel, maximum resistance to abrasion, reasonable first cost, machine ability, resistance to fracture under shock and to crystallization, in one steel—one casting. While this demand has been plain, and in fact, in operation for twenty years, there has been but one real reply—highly specialized alloy steel, and a method of casting, together with ordinary soft steel into one solid piece, the resultant casting having a wear-proof alloy steel stratum upon the wearing surfaces, while the body of the casting is composed of ordinary cast steel of any desired carbon content. This alloy can neither come loose, nor spall, nor spread, or flow. Its depth or thickness, its location and its hardness are completely controlled and are varied according to the size of the piece and the nature of service expected.

Before proceeding with the development of this process and its definite application to the steel industry, we will consider briefly the various means that have been used and are now available for increasing the wear resistant qualities of steel used for transmission purposes in general.

They can be divided in four general groups:

A. Heat treatment of high carbon or carbon alloy steels.
B. Case hardening of castings or forgings.
C. Alloy steels—such as Manganese Steel.
D. Composite Steels.

Heat Treatment of Steel.

In the first case, that of heat treating, we must consider briefly what occurs when a carbon steel or an alloy steel is hardened and tempered. It is not the purpose of this paper to go into the details of the theory of the changes, but a few remarks are, I believe, pertinent. You are all more or less familiar with the various theories of the iron carbon solution premise and they will not be dealt with here.

Any steel (.30 per cent) if it be raised to a bright red heat and then rapidly cooled, as, for example, by plunging it in water, becomes very much harder and at the same time stronger and more brittle. There are several theories advanced for this change, notably the carbon theory and the allotropic theory. They are aside from the issue, however.

We need but consider the fact that steel can be heat treated in this way. This method, however, assumes that a high grade steel is used and it must be remembered that this method is expensive, and that all portions of the forging or casting receiving the sudden drop in temperature when plunged takes on a hardness and only by the use of high grade steels, and where total surface hardness is satisfactory, can it be used with success. Methods, of course, can be followed that will allow localization of the hardened portions, but they are, in general, rather cumbersome and this method, by general consent is used mostly for small pinions, cams and other kindred articles. We are excepting, of course, the use of this type of material and this method as applied to tools and the tool room requirements.

The cost of parts made by this method is relatively high in cost per pound, however, inasmuch as it can only be successfully applied on small parts, there is a certain field where it is quite satisfactory for wearing problems.

(C) Case Hardened Products

We are all familiar with case hardening. The result sought is, in most cases, the production of a hard wear resisting surface upon a tough ductile core. It is, therefore, applicable to any part in the steel plant, where a combination of toughness and a wear resisting surface is desired. The composition of the steel suitable for case hardening is limited by the desire to eliminate any elements that produce brittleness in the core and also any that tend to retard the absorption of carbon by the steel. That is exactly what case hardening is; the absorption of carbon making a stratum of high carbon steel over the original core. A high carbon steel has certain differences in physical properties from a low carbon steel. This, in the finished piece, presents some difficulties. The size of case hardened parts is not limited except by the size of the furnace available. The surface presented is, while hard, extremely brittle and acts somewhat as glass does. If a small crack starts it rapidly spreads, and of course, spalling out through shock or impact is a familiar fault.

Case hardening has one great advantage. Parts can be so treated, either before or after machining, and where a machine surface is necessary for mechanical reasons this method can be used to advantage. A large number of parts for a steel plant are hardened by this method, but those parts subjected to severe shocks, present problems that this type of heat treatment will not solve.

The cost of ordinary case hardening is not excessive, considering the extra wear, but it is in the last analysis only a compromise between soft steel and hard steel, and presents the real solution for wearing problems only in a few definite applications.

(3) There is a third class of steels used where wear is encountered. They are the alloy steels and almost every known alloy has been used in the attempt to secure suitable material for the many diversified problems of the modern steel plant. Let us eliminate the alloys used in rolls and shafting and other kindred parts and limit ourselves to the question of wearing parts.

The two Alloy Steels mostly used for this work are the Manganese Steel and the Chrome Steel.

(a) Manganese steel is an iron carbon alloy containing 11 to 13 per cent manganese. Its hardness is not that of tool steel, but rather a toughness of extreme resistance. Right after being cast Manganese steel is too brittle for any practical purpose. By proper re-heating and quenching a quality of tough ductility can be imparted to it. No definite physical characteristics can be given for Manganese steel, as the heat treatment in each case determines them. It is difficult to get uniformity in Manganese products. This steel cannot be machined by the ordinary machine tool methods, but can only be finished by grinding. This means that bushings of soft steel must in most cases be inserted in the casting.

On account of the abnormal shrinkage and the necessity of heat treatment, special patterns must be made especially for Manganese steel.

Certain parts can be made of Manganese steel most successfully. In the case of chains, teeth, pulverizing hammers and certain crushing parts, Manganese is in a field by itself. On large castings where only a small portion of the entire casting is subject to wear it is expensive and its lack of uniformity gives it a problematical value for a great many uses. We will take up the specific advantages of Manganese steel for certain work in the steel plant later.

Naturally, Manganese steel containing such a large quantity of alloy and as it is necesessary to heat treat each individual casting it is expensive to manufacture, and the cost of the finished piece must also include the cost of certain grinding operations.

(b) The only other steel used extensively for this type of work is Chrome or Chrome Nickel Steels. Its real field is that of crushing silicious materials. It has somewhat the same characteristics as Manganese steel, but it is not in such universal use.

It is used considerably for grinding balls, liner plates and such kindred applications.

Chrome steel is slightly more expensive than Manganese steel, due not so much to its manufacturing cost per ton, but the fact that its use is so limited that it is a special job in almost any plant manufacturing it, and in a great many instances calls for somewhat special equipment.

Chrome Nickel steel is similar to Chrome steel except that there is an added toughness thereto which gives it advantages where torsion and shear might be encountered.

(C) Composite Steel

There is another method used to obtain wear proof qualities, and that is what might, for want of a better name, be called "composite steel structure." Certain efforts have been made to make steels of this type by certain methods, but there is only one in general use.

In this the alloy can neither become loose, nor spall, nor spread, nor flow. Its depth or thickness, its location and its hardness are completely controlled

and are varied according to the size of the piece, and the nature of the service rendered. This gives a casting that has the necessary wear proof qualities in the portions subjected to wear, and only there—the remainder of the casting is of ordinary carbon steel with its attendant advantages of low cost, ease of machining, resilience under shock, etc.

The actual percentage of the weight of a steel casting that is worn away in practice is generally very small. The teeth of the average gear wheel constitute less than ten per cent of the total weight. A worn tooth weighs half as much as a new one. Therefore, ninety-five per cent of the gear wheel casting has been used only for supporting weight or carrying stress and is never worn out.

It is quite obvious that a hard material is of no benefit in this greater portion and is nearly always detrimental, both on account of the expense of machining and the very nature of high carbon or alloy steel. While this special alloy is the greatest wear resistant steel known it is, of course, impractical to cast it in an entire casting. Its cost is in the neighborhood of one dollar fifty cents per pound. But to get such an alloy in and on the part subjected to actual abrasion, and still to keep the easily machined and cheaper steel in the other ninety-five per cent, means to combine the advantages of both at a cost of about three cents per pound additional instead of one dollar and a half.

Let us consider some of the physical and chemical characteristics of this special steel casting.

In general, this alloy is superimposed on four grades of ordinary carbon steel.

One grade of a carbon content between 18-22 carbon, which is the lowest carbon content that will work successfully with it. The next is a steel of 25-35 carbon, followed by one of 45-55 carbon, and the highest carbon content used is 70-80 carbon. The portion of the casting consisting of ordinary carbon steel has all the chemical and physical properties of steel castings required by the American Society for testing materials except that the phosphorus and sulphur are usually well under the permissible limit. There is no need of going into these properties—they are familiar to all of you.

The physical properties of this Alloy coincide in a great many respects with the properties of the soft steel base. By this I mean strength in tension compression and shear. The co-efficient of expansion is identical with that of the base steel and the shrinkage in the mold when being poured and cooled is also the same.

The alloy is extremely hard, running about 80-85 scleroscope.

It is also extraordinarily tough. It can be bent under the skull cracker thirty degrees before breaking.

It can not be machined, and where it needs finished surfaces grinding must be resorted to.

It will not peen cold, and as before mentioned, will not spread nor flow.

It is not a compromise or an offspring of any of the various methods in the past or now in use for creating wear proof steel.

We are primarily interested in this discussion with this special alloy and its uses and results in steel plants. This covers a wide and diversified field, and can probably be better presented by first outlining the uses in the various general groups of steel mill casting and then under the head of the various types of plants take up the specific definite applications with an idea of service records and costs.

(a) Gears and pinions made by this process have the face of the teeth only hardened by the alloy. The depth of this layer of alloy will vary with the thickness of the tooth, but in every event the depth of the alloy is as great as the amount of tooth worn out in service.

The fact that the alloy can't be machined makes it impossible to furnish this material in any gear or pinion job except where a cast tooth can be used. The tooth is no smoother or rougher than an ordinary cast tooth, but due to a peculiarity of this alloy, the average efficiency of transmission is much higher than in the case of cast tooth gears and a great many cut tooth gears. This particular property is because of the fact that approximately eighty per cent of the wearing life occurs, while the original contours are maintained. In other words,

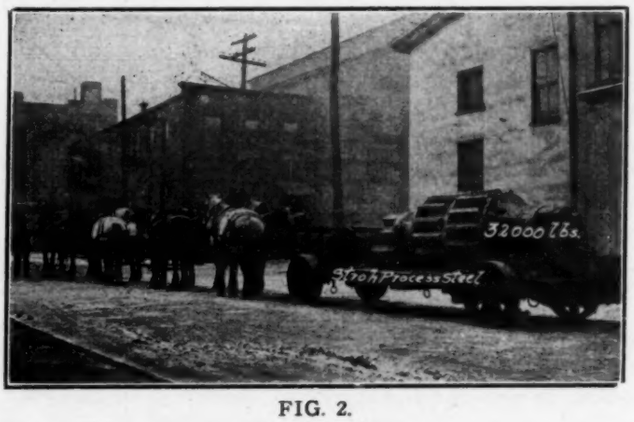

FIG. 2.

after the gears are nicely worn in and their maximum efficiency of transmission attained this efficiency stays almost at a constant figure during the major portion of their life.

Any tooth profile or style of tooth that can be cast can be made successfully by this process, but very small teeth and small C P. presents some difficulties. As a general thing, however, any gear that is used around a steel plant, excepting, of course, those gears and pinions whose work inherently demand cut teeth can and has been made successfully in this alloy.

As is characteristic with this process, the hubs and other parts of these gears and pinions can be machined with ease and the alloy presents another feature of major importance. There is no heat treatment in making over gears and pinions, and therefore, the alloy remains hard under all normal or abnormal temperatures. Pinions and gears can thus be heated up for shrinking on shafts without any detrimental effects on the wearing portions thereof.

(b) We make mill pinions of all sizes and types, including helical, spur, staggered spur and herringbone. In the case of these castings, not only the teeth, but also the shrouds and wabblers are hardened by the alloy. On account of the size and weight of the greater portion of mill pinions the

price of mill pinions is a considerable item, but its strategic position at the source of rolling operations makes that consideration secondary to dependability, resistance to fracture and to wear.

The fact that a great portion of the life of the pinion occurs during the time the original contour of the teeth remains, is of vital importance.

Assuming for illustration, teeth 3 in. thick at pitch line, ⅛ in. clearance; the impact at point of greatest back lash is controlled by this ⅛ in. When ¼ in. has been worn off from each side of tooth the controlling distance is ⅛ in. plus 4 times ¼ in, or 1⅛ in.; nine times the original, and the tooth is now only 2½ in. thick.

Now, the impact of a given mass varies with the velocity, the velocity varies as the distance through which the driving force acts and the resistance of any steel to impact is only a portion of its resistance to direct pressure. On a pinion only slightly worn you have multiplied impact and decreased resistance. This process casting reduces impact and maintains resistance. (c) Spindles and boxes with wabblers, and pods hardened by this process give economies of operation far in excess of the slightly greater cost of the alloy application.

In the case of spindles, the machine work on the bearings can be done with ease and on a six-

FIG. 3.

ton spindle only about 300 pounds of metal is worn away in service. As shock and back lash are at a minimum, due to the close clearances during almost the entire life of either the spindle or the coupling box, there is a distinct saving to all parts of the mechanism from the power source to the last roller. Destructive impact is at a minimum.

(d) A special application is that of shear blades for blooming mill shears. These are cast with the cutting edges composed of the alloy and holes cast in the body of the casting. The cutting edges, after leaving the foundry floor are given a machine finish grind on the six sides, and the blades are finished ready for installation. Among other special castings composed of the same type of material are guides of all descriptions, binding boxes and piercing dies for tube mills.

(e) The ability to control not only the location but the depth of the alloy is nowhere as well exemplified as in the case of crusher parts. Crushing jaws and plates, crusher heads and slugger rolls are being regularly furnished in this steel. It differs from other material used for this sort of work in three cardinal ways. First, due to the fact that the alloy is located only on the portions subjected to wear, makes it possible for castings to be furnished whose other portions can be machined cheaply, allowing for easy installation. Then again, the alloy will positively not flow. This is important in heavy duty work and no other metal except Chrome steel has this feature. Lastly, and by far the most important, is the fact that on corrugated parts the alloy is placed heavier on the projections than in the depressions with the result that when the inevitable wear does occur the depressions wear as fast as the projections and thus the differential distance from projection to depression remains constant. This greatly adds to the total life of the casting and keeps it cutting efficiency constant throughout its life. This is not true of any homogeneous material which wears off gradually to a flat surface.

(f) A feature of ten years ago but now a big factor is the Hammered Crane Track Wheel.

Originally this alloy crane wheel was made in the same manner as any regular casting except that the tread and flanges were composed of alloy. Obviously it was found necessary to grind these wheels to get them to correct diameters and proper dimensions of flange and tread. Unfortunately this grinding sometimes removed some of the alloy and after attaining a true circumference the depth of the alloy might vary. For this reason it was felt that some other means had to be found to properly manufacture these wheels and after several years of intensive experimental work a method of hammering the treads and flanges to correct sizes was developed

The wheel is cast in the ordinary manner as any other cast wheel, except that the treads are hardened, but it is cast oversize a predetermined amount. It is annealed and rough bored and then sent to the finishing plant. In this plant are located the hammering machines. They consist of five roll heads, three motor driven and two followers. Rolls of the proper size for the desired contours are placed in the machine and the wheel heated up to 1400 deg. F is placed in the machine and under 100,000 hammer contacts per minute, are beaten to form and finish. They are then given a finish grind to exact size and contour. One can readily see the advantages of a wheel of this sort. Its hammer finish to rim has all of the alloy uniformly distributed, has a hammered rather than a cast structure and combines the rigidity of the casting with the solidity of the forging.

The flanges of this wheel cannot break for they have a backing of mild steel and the alloy itself is tough, bending 30 degrees before rupture.

These wheels are practically wear-proof, being very hard (90-95 scleroscope.) The flanges can't spread as the alloy will not peen cold.

There are no troublesome cores in the hub and machine work thereon can be handled by ordinary methods. While this wheel is hard it holds the rail well. It has an acceleration of 3 miles per hour per second and a deceleration of 5 miles per hour per second far in excess of normal crane requirements.

Nowhere is there greater lack of standardization than with crane wheels and an attempt to arrive at a series of standard wheels that would meet most operating conditions has been accomplished.

The Standard hammered crane track wheel runs from 18 inches to 30 inches with diameters and contours selected as the consensus of opinion after comparing several hundred working drawings, to

gether with the constructive criticism of the chief engineers of many of the large crane builders. As regards diameters, the Standard wheel will meet about 80 per cent of the conditions.

Throat radii, width of tread, height and thickness of flanges and angle of flange interior show greater

FIG. 4.

variation, but within practical limits 85 per cent of the demand can be covered by one of these wheels.

The greatest variation, is in hub dimensions. On this account standard patterns are arranged to cast any hub desired.

In addition to these standard wheels any type of single, double or no flange wheels can be made.

Experience with wheels leads to the belief that the flange and tread contour remain at original dimensions during ninety per cent of the life of the wheel. This is a big factor in low maintenance.

A comparison here of various types of wheels may be of interest at this time. A list of their advantages and disadvantages are submitted herewith:

Chilled Iron Wheel—

Advantages—Low initial cost. One wear wheel.

Disadvantages—Heavy in weight for its strength. There is a tendency for the flanges to crack. Flat spots will not iron themselves out in service. Imperfect rotundity.

Rolled Wheel—

Advantages—Low first cost in comparison to wear. Flat spots if developed will iron themselves out.

Disadvantages—Heavier in weight than other wheels for same strength. This is due to certain manufacturing reasons and not to strength of the material. Flanges wear rapidly and scarfing occurs. Cost of redressing runs into considerable expense. There is a tendency to crack under shock. Due to method of manufacture perfect rotundity is not assured. If a heat treated product it is subject to faults of case hardening.

The Manganese Wheel—

Advantages—Low cost in proportion to service rendered. It is primarily a one wear wheel with the attendant advantages.

Disadvantages—As is true with all Manganese steel heat treatment is necessary and lack of uniformity is liable to occur. If this heat treatment is faulty flanges will spread or break out and spalling out of tread is a common fault. If the wheel is properly heat treated it will not iron out flat spots. Either an inserted bushing is necessary at the hub or the preparation of the hub will have to be done by grinding. Special patterns are necessary to cast these wheels and a large amount of grinding of tread and flange contours are necessary which adds to cost of wheel. The hardness of the tread causes low acceleration and deceleration factors, i. e., the co-efficient of friction is comparatively low.

The Special Alloy Wheel—

Advantages—Light in weight in comparison to strength. The flanges retain their contours during 90 per cent of their life. Less tendency to break under shock, due to the low carbon content of the major portions of the casting. The nature of the alloy allows the flat spots, if developed, to iron themselves out. All strains are rewound by the hammering process and the double annealing. The flanges can't break nor spread. The tread will not spall out nor flow. Perfect rotundity and machine ground treads causes less wear on rails. Ease of

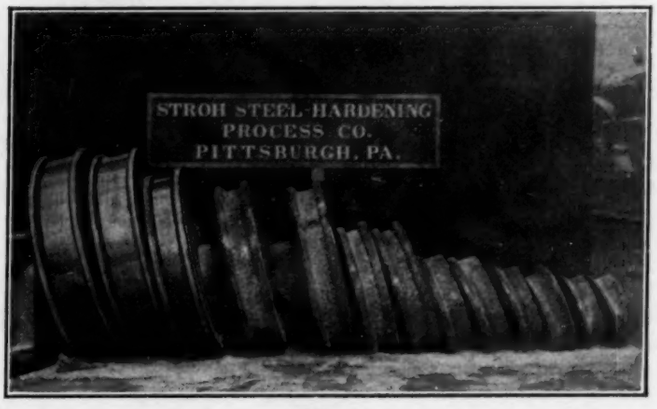

FIG. 5.

machining hubs due to low carbon steel. High values of acceleration and deceleration factors. It is not a heat treated wheel and thus absolute uniformity is assured.

(D) We will now consider definite applications of parts especially prepared to withstand wear used in the steel industry. To make comparisons entirely fair and to put them on a uniform basis we have attempted to reduce all costs and service records to an ordinary cast steel basis. This will allow any one using various types of wear proof parts to compare the service of special alloy steel with the particular material now being used.

(1) We will first consider the blast furnace and the parts thereon subject to sufficient wear to make the use of a special steel necessary.

(a) Skip hoist wheels. The service here is severe and flange breakage and wear important factors. Wheels furnished for this service are manufactured by the regular method and have been used at a large number of furnaces. The life of these wheels, based on a number of service records, indicate that special alloy wheels are lasting over eight times as long as cast steel wheels, while the cost is only 62 per cent greater.

(b) Pinions for snitering machines. Here again there is a need of a specially treated forging or casting—one that will stand abrasion, not only of steel against steel, but also that due to floating dust and other foreign matters. In this work special alloy steel has service records of four to five times the service of cast steel and is furnished at a cost of about twice as much.

(c) Paddles for snitering machines with the wearing portions hardened by the special alloy are used in a number of plants, but no actual service records are available.

(e) Elevator gears where cast teeth are used have been furnished in this alloy for a number of years. Six times ordinary steel life is the average obtained and the cost of these castings is about 100 per cent of ordinary ones.

(f) Sheaves for hoists, with the treads hardened by this alloy and the spokes of wrought iron have been in use not only at Blast furnaces, but at many mining operations. The service records cover such a wide range of values (from twice to ten times ordinary cast steel sheaves) that no fair average can be given.

2. In the open hearth there are several places where this steel can be used to advantage.

(a) Probably the most severe work is that to which the pusher pinions are subjected. Not only is there a large amount of wear, but there is considerable shock during operations. The wear proof teeth with the high elastic limit of the core makes these pinions ideal for the work encountered. The life of these pinions has been averaging three and one-half times that of ordinary steel and the castings, machined complete sell at about 22c per pound.

(b) A unique application of the process around the open hearth is that of hardening the heads of charging peels. The absence of wear over long periods allows a closer fit on the charging boxes and their ability to be charged fuller. In addition, many users claim that fire crack checks are elimmated. These peels cost about 50 per cent more than ordinary ones, but their life is eight to ten times as great.

3. Rolling Mills.

Resistance to wear and ability to withstand shocks are primary requisites in all rolling mill work.

In the larger castings, however, only a small part of the entire casting is subjected to wear and the remainder is only used to carry the stresses. Obviously a composite steel answers these requirements. Those parts subject to wear and only those parts are composed of a wear resistant material. The other portions are of the proper carbon content for the work to which they are put.

(a) Spindles, boxes and various crab couplings naturally fall into this class. These have been made in this steel for years and as they cover a long range of service and have so many applications no specific records of their life can be shown by average. The life of spindles runs from 10 to 40 times soft steel. These cost about 2c per pound more than regular spindles.

The coupling boxes show a life of from six to ten times that of soft steel and cost about 3c per pound additional.

(b) Rolling mill pinions, as before outlined, are made with any size or design of tooth. Their use is limited only by high peripheral speeds (as on wire mills) where a cut tooth is essential for kinematic reasons. The larger mill pinions average six times the life, while the smaller ones (around 10 in.-12 in. P.D.,) average four to five times that of soft steel. Their cost is about 5c per pound additional. The teeth, shrouds and wabblers are composed of this special alloy.

(c) Table gears, while in the past made successfully by this process, are now almost exclusively furnished in cut teeth. This, due no doubt to the attendant noise when cast teeth were used and the fairly high speeds.

(d) Shear knives, for hot billet shearing, is another very successful application. As before explained, the edges are machined, ground to size and the holes cored in. No machine work is necessary. Seventy to eighty thousand cuts of a 9¾ in. billet is uniformly obtained at one of the large steel mills in the Pittsburgh district.

Incidentally, several large plants in the Sheffield district in England are regularly supplied with these knives.

Knives cost about 15c to 16c per pound finished ready for installation.

(e) Guides, bending dies and boxes are regularly furnished to a large number of rod and tube mills. Their average life is from five to eight times cast iron generally used for this purpose and their cost, ground ready for installation, is about 18c per pound, depending on their size.

4. Cranes.

We have outlined heretofore in detail the method of manufacture of these wheels.

Standardization of contours has greatly reduced their cost and while their life is from four to six times that of a cast wheel their cost is nominal. For example, a 24 in standard wheel for an eighty-pound rail sells for $79.00, rough bored, but otherwise ready for installation. As compared to usual alloy steel wheels, the cost of machining the hub is much less and there are no broken or spread flanges to give trouble and no inserted bushings to come loose.

5. Crushing Parts.

The resistance of this steel to grinding action, its inability to flow and the possibility of localizing

its position, depth and hardness makes this material a desirable one for crushing parts of all descriptions, whether jams, plates, roll heads or pushers.

Service conditions vary too much to make it possible to give any definite records as to the life of these parts. This type of casting costs about twice that of a straight high carbon steel.

(6) For the general transmission work around a steel plant these hardened castings should be used for:

Gears and pinions (where cast tooth can be used.)

Sprockets.

Sheaves (These also are hammered.)

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*Discussion: Extending the Heat Cycle in Boiler Rooms by the Use of Preheated Air for Combustion Purposes**

John VanBrunt†: I have read Mr. Worker's paper with much interest and quite agree with his statement that "one of the outstanding achievements in combustion is the use of preheated air." One of the interesting phenomena observed in the use of preheated air in connection with underfeed stokers is the improvement in fuel bed conditions and furnace performance, and the fact that in consequence of this improvement the gain in efficiency may be greater than that due to the heat returned to the furnace by the preheated air.

The total gain, therefore, may be divided in two parts: first, the gain due to the B.T.U. supplied to the furnace in the hot air or that due to the lowered flue gas temperature. This gain may be calculated and predicted. The second part is an indeterminate gain, due to improved furnace conditions, such as lower carbon loss in ash pit, higher CO_2 thinner fuel bed, hence lower draft pressure and less carbon blown through the boiler. The sum of these changes in fire conditions will vary in magnitude and with different kinds of coal, quality of ash, etc. With chain grate stokers similar indeterminate gains may be had. Expressed in per cent increased efficiency, this improvement in furnace conditions may be as much as 2% in some cases and as little as ½% in others In most cases the amount will be sufficient to pay for the increased draft loss due to the air preheater.

Regarding the possibility of extending the heat cycle beyond that done in the past, I think that Mr. Worker has not given consideration to the practical limitations that stand in the way. From a theoretical standpoint, it is possible to extend this heat cycle by the use of an economizer considerably below that possible with an air preheater. For example, assume water entering an economizer at 70° as compared to air entering a preheater at the same temperature. In the case of the water economizer the tube temperature will be approximately that of the water or 70°, while in the air preheater the metal temperature will be about half way between the 70° and the temperature of the gas on the opposite side of the plate.

In preheating air there are two distinct transfers and transfer rates, first from gas to metal, second from metal to air. Inasmuch as the heat transferred per square foot of surface will vary directly as the temperature difference, it will be seen that in water economizers the transfer per square foot will be double that for an air heater, for the same temperature difference between gas and air and gas and water, or the rate will be the same with an economizer with half the temperature difference. The above applies to plate and tube heaters or recuperators. The rotary type preheater is a regenerator.

Let us analyze what will happen if we try to extend the heat cycle so that the temperature of the boiler gas leaving the heater is brought down to atmospheric temperatures. As explained above, the metal temperature lies half way between the temperature of gas and of air. In order to have a transference of heat there must be a difference in temperature. At very low temperature differences, say two or three degrees between the gas and metal, the flow would be something like 5 B.T.U. per square foot per hour. The problem would be the same as designing a boiler to bring the flue gas down to the temperature of the water in the boiler. Disregarding radiation the surface required would be infinite, a practical impossibility.

It may be asked, why not bring the gas temperature down to 150°? There are two limiting reasons: first, the cost of the surface required; second, the same limit that has prevented the use of economizers for the same degree of cooling. That reason is condensation of the moisture in the gas on the surface of the economizer tubes or on the air heater plates. True, it is possible with an air heater to lower the gas temperature to a slightly lower figure, but it will not prove economical.

Moisture in flue gas comes from three sources—moisture in the air used for combustion, moisture in the coal and, most important, moisture formed by burning hydrogen. For practical purposes it may be said that for an average bituminous coal of 5% moisture and 4% hydrogen the flue gas will have a dew point of 115° F., which means that, wherever the gas sweeps a surface of this or lower temperature, moisture will be deposited. If then, an air heater is so proportioned that air enters at 50° and

*Paper presented by Mr. J. C. Worker, before Twentieth Annual Convention.

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gas leaves at 150° the temperature of the plate will be about 100° or 15° below the dew point. Condensation will result and with it corrosion. For this reason it is not advisable to design preheaters which will permit plate temperatures below 150° and exit gas temperatures much, if any, below 230°.

Let us see what further improvement may be made in the overall efficiency of some of the recent pulverized fuel installations. There are two well known plants which now have a monthly operating efficiency of approximately 90%, which includes banking and periods of low and high capacity operation. The boiler operating efficiency is probably 91%, leaving 9% for all losses. These losses are about as follows—hydrogen 4.25%, or half of the total loss; dry chimney gas 3.5%; radiation .75%; combustible loss .5%.

In this case the dry gas leaves economizer at 230°F. and analyzes about 15% CO_2. We cannot possibly decrease the radiation loss, nor is it possible to reduce the combustible loss particularly as the assumed figure of 5% is probably excessive. The hydrogen loss cannot be recovered except by condensing all the vapor which would necessitate lowering the gas temperature to the freezing point. There remains only the dry gas loss of 3.5%. To gain one per cent here the temperature must be reduced to 150° or thereabout, with resulting condensation and corrosion.

The commercial consideration of air preheating is the same as for economizers. Will the increased efficiency in saving in fuel be enough to carry the fixed charges, power, repairs and return a reasonable profit on the additional investment? In general, it may be assumed that the cost per square foot of surface will be slightly less in large preheaters than in small ones and, further, the cost of the first 100° of preheat will depend on the temperature of the flue gas entering the heater. If the heater follows a large economizer it may be economically impossible to obtain 100° preheat.

In reference to the care of preheaters, much depends on the application. A deposit of tar or soot is a clear indication of faulty combustion or unconsumed hydrocarbons. The plate heater is, in the writer's opinion, more easily operated and cleaned than either the rotary or tube type. With pulverized coal the deposit is a fine powdery ash and with plate heaters this ash will not accumulate. The movement of the plates due to variation of draft and air pressure causes the ash to fall from the plates as fast as it accumulates. Tests have shown that after cleaning the gas temperature will rise about 15° in two hours, and will not rise further in the next twenty-four hours.

In any discussion of preheated air, mention should be made of its effect on furnace temperature and, hence, on the furnace refractories. It is now generally understood that one of the principal causes of the destruction of furnace brickwork is the deposit of molten or fluid fly ash on the surface of the brick already heated to a temperature equal to the melting point of the ash. The result is erosion or wasting away of the brick, although the temperature may be several hundred degrees below the melting point of the fire brick.

The use of preheated air may result in an increase in CO_2, which means a higher temperature in the furnace, on top of which is added another increase due to the temperature of the air. The total increase in temperature may, therefore, be 200° or 300° which may be considerably above the melting point of ash and result in excessive maintenance. How, then, may this excessive maintenance be avoided? By lowering the CO_2? No, because much of the gain due to heated air would be lost.

In order to retain the benefits due to preheated air it becomes necessary to cool the walls below the temperature of ash fusion. Air cooled walls have been successfully used, but where the ash softening temperature is very low such air cooling is not sufficiently effective. The next step, therefore, is water cooling.

Mr. Worker illustrated three general types; air cooled, part water cooled and full water cooled. The full water cooled are, naturally, all metal walls; that is, the fin tube and the cast iron jacketed tube. A fourth type, not mentioned, is the thin refractory block backed by cast iron plates which, in turn, are clamped or bolted to water tubes. Of the full water cooled walls, the fin tube is the first development and remains the simplest and most effective.

A water tube screen composed of plain vertical or inclined tubes spaced 10" to 14" apart will afford protection to brickwork, but a thick brick wall must be employed. Why not make the fullest possible use of the water cooled idea and provide an all metal water cooled surface with a light insulation back of it, thus eliminating many thousand brick?

As is well known, the heat absorbed by radiation in the row of boiler tubes next to the fire will evaporate 50 to 70 pounds of water per square foot of exposed tube surface, the exact amount depending on several factors, such as the temperature of the furnace or flame or fuel bed, and the amount of surface exposed; or expressed in another way, the pounds of coal burned per square foot of exposed tube surface. The addition of more exposed surface in water cooled side walls will lower the furnace temperature an amount depending on the total exposed surface provided. The rate of absorption per square foot will then be lower than where only boiler tubes are exposed, but in almost any case will be equivalent to 30 or 35 or more pounds evaporation per square foot, depending on the ratio of coal burned per square foot of exposed surface.

Water cooled walls of any type are expensive because of the construction necessary. Therefore, why not take full advantage and secure the greatest possible amount of work from them by fully utilizing their possibilities? While this is intended as a discussion of air preheating, it seems desirable to emphasize the use of water cooled walls as a corrollary equipment necessary to fully utilize the benefits to be obtained from preheated air.

Each will show a satisfactory return on its cost. Air heaters will improve combustion and efficiency from four to seven per cent or more, the full water cooled walls will eliminate furnace repairs which may amount to several thousand dollars per year per boiler, and in addition reduce radiation losses by one-half or three-quarters per cent, and reduce exit gas temperatures 25° to 50°, equal to one-half to one and one-half per cent gain in efficiency, besides reducing boiler outage.

The writer believes that air preheaters are rapidly becoming a standard equipment for large boiler installations, either stoker or pulverized coal fired, and that equally the full water cooled furnace wall with bare tubes will soon be accepted as a standard form of furnace design.

Mr. Worker shows a curve of B.T.U. liberated per cubic foot of furnace at West Penn, Lake Shore, Cleveland, Lakeside, Milwaukee and Cahokia, and also a similar curve for a modern stoker. From the fact that the latter curve is dotted raises the thought that it is a calculated curve. The purpose of these curves is evidently to show that in a modern stoker setting it is possible to burn more coal per cubic foot of furnace volume than with pulverized coal. These curves are not truly comparative because of great differences in exit gas temperatures, and because of differences in boiler types and number of tubes and passes.

The tabulated comparison of stoker stations and pulverized coal stations is interesting, but neither complete nor convincing. The average operating capacity and the monthly efficiency, if added to the table, would tell a very different story.

To conclude, I would say that Mr. Worker's paper is timely and points the way to simple and effective means to better efficiency and to improved furnace design. I do not think, however, that the air preheater, however valuable an adjunct to the modern boiler, will make possible any extension of the heat cycle beyond what is now current practice.

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*History and Future of Radio**

By S. M. KINTNER†

TWENTY-FIVE years ago anyone with the audacity to claim that man could talk across the ocean, and even to people aboard ships in mid-ocean, would have been adjudged crazy.

Today a statement of such a feat is given only passing notice. The difference is simply one of before and after the accomplishment.

Less than a hundred years ago the basic principle upon which our entire electrical industry is founded was unknown. From Michael Farraday's simple and apparently unimportant observation, that when an electric current was established, or broken, in one wire, a momentary current was set up in an adjacent one, has grown this giant industry upon which our present-day life is so dependent.

While these two observations have no direct bearing upon the subject I am about to discuss, they do indicate quite forcefully two points I would like to make: (1) the comparatively short time we have had an electrical art, and (2) our peculiar state of mind regarding things with which we are familiar.

Referring further to this last point, it is doubtless within the experience of all of you how marvelous and mysterious some machine has appeared the first time you saw it perform. Also, how this feeling of awe and mystery gradually melted away as you saw it more and more often until finally, after you had learned how to operate it, you began to feel that it wasn't mysterious at all and that you knew all about it. Of course, you didn't know all about it, or even very much about it, but you gradually arrived at the conclusion where you were satisfied with your ignorance and content to follow a rule for operating the machine and accepting the performance as natural results.

Fortunately, radio is less subject to this condition than most other things and to this fact, I believe, a large part of its present popularity is due.

You electrical engineers have no doubt all had the classical question of "what is electricity?" asked of you by some "old friend of the family" after your return from college. You probably felt ashamed at not being able to answer and the "old friend" doubtless thought you had been wasting your time, and yet neither of you stopped to think of how many other things you were equally ignorant, although they were known to exist, and to have been in daily use centuries before electricity was discovered.

There is always comfort in company and we electrical engineers find ours in knowing that light, heat, gravity, inertia, etc., are all as mysterious as electricity, and how many of the millions of users give a thought to their ignorance of them.

Fortunately, all of mankind is not satisfied with this condition and so some individuals spend their lives in seeking answers to nature's problems.

To these pioneers we owe much of our engineering advancement. Very few, if any, of our revolutionizing discoveries or inventions have resulted directly from someone starting a search for them. Radio is no exception. Hertz undertook his work to prove the correctness, or falsity of Maxwell's theory of light. When he had accomplished that, by producing electromagnetic waves which were successfully subjected to all the tests of light waves, his work was finished. Other experimenters improved parts of Hertz' apparatus and thus made more certain and easy of accomplishment, the several demonstrations he had devised. To Sir William Crookes is due the credit for first recognizing that a means of communication without connecting wires could be constructed from Hertz apparatus. He published a note in the February, 1892, Fortnightly Review, calling attention to the possibilities of such a system for a telegraphic service. Marconi was the first to seriously undertake the development of such a system. Marconi was not a scientist; he was a young engineer with a keen business sense and with sufficient energy and vision to enable him to work through the pioneer stages successfully.

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He utilized the existing facilities and bent his energies to improving those most in need of it. His system was but a glorified Hertz system with parts built more ruggedly and with a more sensitive form of receiving spark gap than that employed by Hertz.

It is to these particular facts that I direct your attention: (1) that Marconi followed Hertz in producing his radiations by using spark discharges and thus setting up high frequency oscillations in his transmitter, and (2) that he relied upon a breaking down of a bad contact in his receiving circuit to indicate the receipt of the signal waves. He clung most tenaciously to both of these principles of operation until he was gradually driven from them by overwhelming proof of their inferiority. It is not difficult to understand why he should have been thus fooled if one reads the technical literature of that time. In that one finds unstinted praise of Marconi's coherer, an invention of Bronley and named by Lodge, as the most sensitive device ever conceived by man. Fancifully termed the "electric eye" and generally recognized as the device that made radio possible. With the coherer as a detector, the spark discharge method of producing radiation was best and thus Marconi's friends and admirers by their praise, helped to fool him and to delay his start along lines whose principles have been shown conclusively to be the better ones.

While others praised, followed and imitated Marconi, there was one worker in Pittsburgh, who announced to me among others, that the Marconi system was wrong and that radio could never succeed along such lines. He stated that the detecting means should give a response proportional to the received energy, instead of, as in the case of the Marconi coherer, giving signals that all sounded alike.

It took courage and a firm conviction of the correctness of his stand for Fessenden to tell the scientific world that this marvelous new invention of Marconi's was wrong, yet that is just what he did. He didn't stop at telling, but proceeded to prove it by devising a different and better one.

Fessenden's attack centered on the coherer and he devised several devices to replace the coherer—all giving responses proportional to the received energy. I am dwelling on this circumstance because I believe it to have been one of the important turning points in the development of the art.

Whereas Marconi's receiver recorded its messages by means of a telegraph printer, Fessenden's was taken down manually by an operator who listened with telephone receivers.

With Fessenden's receiving means it was soon noticed that there existed certain characteristic differences in transmitting stations that enabled the operators to recognize one from another by qualities of their transmission that distinguished them, just as individuals are recognized by differences in the qualities of their voices.

Radio Telephone

It soon occurred to Fessenden that these differences in transmitter qualities were due to peculiar radiation differences and he reasoned that if means could be found to control the radiation intensity synchronously with the voice it would be possible to telephone by radio. He did this by simply placing an ordinary wire line microphone in the antenna circuit of a very high spark frequency radio transmitter, and while his assistant talked Fessenden listened at a nearby radio telegraph receiving station and heard the familiar "hello" as it made its first trip by radio. This was the birth of the radio telephone and one of the important results that followed Fessenden's departure from the teachings of Marconi. This discovery was made in 1901.

Continuous Waves

The desirability of more sustained radiation was another need made manifest to Fessenden by his type of receiver. This led him to the invention of the continuous wave transmitters. He proposed to secure such result by directly connecting one terminal of a high frequency alternator to an antenna and the other terminal to ground. To those of you who do not remember the art as it was prior to the employment of continuous waves, this does not sound like much of an invention. To you I can but say the record furnished by the several editions of J. A. Fleming's book entitled "Electro-magnetic Waves," is most convincing evidence that it was an invention of a high order. In the 1906 edition Fleming, then the technical advisor of the parent English Marconi Co, reviewed the Fessenden patent, in which the continuous wave method was, first disclosed, and said it wouldn't work. It is needless to add that subsequent editions make no such statement. Today, continuous waves are recognized as the standard practice of the best stations throughout the world. This brief statement should be sufficient on this point.

Heterodyne

Continuous waves for telegraph service did all that was expected of them in improving tuning conditions, but something more was needed to make them readily readable by the receiving operator. In the case of spark sets each spark makes its own click of the telephone diaphragm and, if increased in number and regularly spaced in time, these clicks grow into a musical tone so the operator could readily hear the incoming musical tones of short, or long duration as indicators of dots and dashes of the Morse code. With continuous waves, this is missing, and the listener hears only a click at the beginning and another at the end of a dash or dot. With the extra clicks that may be introduced by static and other interference this does not give the desired certainty of identification of signals. Various expedients of chopping the radiations both at the transmitting and the receiving stations were tried, but all were given up for the Fessenden "beats," or, as he termed it "heterodyne" method. This consisted of combining the incoming signal waves with another set of waves of slightly different frequency, and of listening to the interference, or beat frequency of the two. In this age of familiarity with radio, it is believed to be unnecessary to describe this method more completely.

Suffice it to say that this is the system par-excellence for radio reception.

Vacuum Tube—DeForest's Third—Electrode—Armstrong's Feedback

Up to this point radio had developed without using vacuum tubes, or at least such small use as had been made of them had little influence on the trend of the development.

J. A. Fleming was the first to introduce a vacuum device in about 1905. Fleming made use of a discovery made by Edison that a current would pass from an electrode introduced into an incandescent lamp, more readily from such electrode to the positive end of the filament than it would to the negative end. Fleming found such a device, when applied to a radio receiving circuit, would allow the high frequency currents to pass in one direction but not in the other. It acted just like a check valve, and so it was termed a valve and was generally known as the Fleming valve. Such a device was of about the same order of sensitiveness as a crystal detector, but requiring a battery and control for the filament, was not so convenient.

DeForest added the next step in the march of progress in the vacuum tube by his introduction of the third or control electrode. This was a typical illustration of "necessity the mother of invention." DeForest had lost in a contest with Fessenden on the ownership of the electrolytic detector and was enjoined by the court from further use of it. In his extremity, with several hundred sets of leased apparatus about to be stopped, he made his improvement on the Fleming valve and tided over his difficulty.

While the DeForest improvement made the Fleming valve thus altered somewhat better, it was not enough so in its then stage of development to cause its very general adoption. Thus, during the years 1906 to 1913, there were several types of detectors in use with little choice between them, excepting on ease of manipulation.

Of these the following were the best known—the Fessenden electrolytic or liquid barretter, the crystal rectifiers, the Marconi magnetic, the Fleming valve and the DeForest improvement on the latter, called the audion.

Late in the fall of 1912, Armstrong made his discovery of the feed-back circuit with its wonderful possibilities of amplifying and of oscillation generation.

This discovery brought the vacuum tube to the front at once and many workers started energetic investigations of the tubes and of their related circuits. It is, however, greatly to Armstrong's credit that the explanation then offered by him of the theory of the feed-back circuit is the generally accepted one today. Suffice it to say that Armstrong's discovery made the vacuum tube what it is today, the most important element in radio combinations.

World's War Radio Uses

It was but a short time after Armstrong's invention was generally known that the World War broke out and radio development was directed towards equipment for war purposes. Intensive work was done on radio receiving tubes and great strides were made in the processes of manufacture and improved quality of tubes produced.

Most of the transmitters, aside from those engaged in trans-oceanic operation, were of the spark type, and in the case of the Marconi companies all of their stations, including trans-oceanic, were of the spark type.

Transmitting tubes of any considerable power capabilities had not been developed and, aside from arc transmitters, of which the U. S. Navy had a few sets, there was no other type of generator of high frequency currents within the frequency range needed for the greater part of the service.

At the start of the war the greater part of the radio uses were for ship service. As the war progressed the airplane service took on greater and greater importance and large numbers of phones were equipped with radio transmitters which were used for reporting effects of shell fire and correcting aim, or for reporting enemy movements. Direction finders were also used in numbers and proved of great service in locating the positions of transmitting stations. This was of particular use in locating submarines during the early period of the war, but the danger of being located by direction finders soon became so great that the transmitters were only used in emergencies. Even S.O.S. calls were generally ignored, as the German submarines used this as a means of calling a ship into their range, just like a hunter calls wild turkeys.

At the opening of the war in 1914, Germany had two powerful radio stations in America, capable of communicating directly with companion stations in Germany. One of these stations was complete and in operation, while the other was complete all save a government license to permit it to operate. The U. S. Navy Department supplied this last-mentioned deficiency by taking over the station and then operating it for its owners up until the entrance of this country into the war. During this interval they accumulated a fund of $440,000 profits from their operations of about two and a half years.

When the United States entered the war the Navy was quite well equipped with radio and had very definite ideas as to their additional needs. The reverse was true of the Army, and it was not until a year had passed that the Army was in position to order equipment in quantity. The war had progressed so far that but very little of this apparatus ever got beyond the Army warehouses.

The Navy Department had every ship well equipped and was as well prepared as it could well have been expected to have been. The Navy extended its high-powered stations and would have been prepared to meet, with reasonable satisfaction, the conditions that would have followed had the Germans cut the cables. They erected a large station in France, the Lafayette station, the largest in the world at that time, at the request of Gen. Pershing, to provide against such a contingency, but, apparently the Germans felt themselves better off with the cables intact.

Radio's greatest debt to the war is the stimulation given to tube development.

Entrance of Large Electrical Companies Into Radio

At the close of the war each of the several large companies as a result of their war supplies work had had a taste of radio. Furthermore, they had developed a personnel whose interest in radio was very great and who were very anxious to continue in it.

There was also the probability that further study and work in and with radio would develop methods and appliances adaptable to the normal lines of activities in which these companies were then engaged.

An investigation of the patent rights soon disclosed the fact that none of these several companies could operate successfully without additional patent rights. The seriousness of this deadlock will be apparent when it is recognized that the Marconi company owned the Fleming valve, the basic patent on vacuum tubes. The Western Electric and A. T. & T. companies had a license under the DeForest third electrode patent. The General Electric Company had patents on tungsten filaments and details of glass seals, quite essential for tube manufacture and the Westinghouse Company had the Armstrong feed-back circuits and Fessenden heterodyne system. No one could make a complete set without infringing on the rights of the others. The only reasonable thing that could happen under such circumstances did happen and an agreement with cross licensing resulted.

Perfection of Trans-Oceanic Service

One of the chief concerns of our military leaders, at the close of the war, was that some foreign power would again establish large radio stations within or immediately adjacent to United States territory. They considered the best means of preventing such an occurrence resided in the organization of a powerful operating radio company. This ultimately resulted in the creation of the Radio Corporation of America. It further resulted in legislation limiting foreign ownership in American radio companies to not in excess of 20 per cent.

The Radio Corporation of America set about at once to rehabilitate the large stations it had taken over from the Marconi Company and also to erect an additional one larger than any other in the world. This was done, modern equipment supplied, and the very best systems employed throughout as full patent rights were available to them. With their stations thus equipped they were able to enter into competition with the cable companies and to show a profit on the business thus handled at a rate approximately two-thirds of the cable. The cable companies have since met the rate, but the radio is holding its fair share of the business and will, as its operations improve with time, undoubtedly increase its proportion of messages handled. Approximatel 25 per cent of the trans-oceanic business is now done by radio.

Carrier Current Developments

The development of a system of communication for power companies which would utilize their lines to guide the high frequency waves from one point to all others on the system was the natural outgrowth of an idea which has persisted for a great many years in the telephone art. This idea was ahead of its time, as it lacked a number of instrumentalities which have lately been supplied as they were developed for use in radio operations. This is the first of "other" applications that will likely be made of radio equipment and is growing along in parallel with the development of the radio art.

Carrier current systems have been produced by two classes of designers who have approached the subject from two quite different points of view. One from that of the communication expert and the other from that of the power operator. Each has had his own ideas of how the problem should be attacked. Without undertaking to state what were the activating motives of each in choosing the elements of his system, it is apparent, upon even a superficial examination, that they were quite different as to power requirements. Whereas the communication engineer attempts to operate his system with fractions of a watt, or at most, only a few watts, the power engineer employs several hundred watts.

The power engineer justifies what the communication engineer terms extravagance in power used, on the ground that cost of power is a very minor consideration compared to reliable service.

The power engineer designs with ample margin over and above the worst conditions. A number of careful studies of existing power lines have shown that as operating conditions vary the power requirements of a carrier wave system vary even more. Of course, the communication system is of greatest service to the operators of the power lines at the time when communication conditions are at their worst. It is for such conditions that power requirements must be supplied. Attempts have been made to employ filters and selective circuits which would exclude the extraneous sounds under these adverse conditions, but as only limited success has attended similar efforts to exclude interference from radio receiving sets, it is not to be expected that great success would be had in the carrier wave systems.

It is axiomatic in radio signaling, and should be equally so in carrier current systems, that a certain minimum ratio of signal to interference must not be passed, if reliable signals are to be had. It is within the experience of most, if not all, of you that when listening to a nearby station with your receiver in a comparatively insensitive condition, you heard very little interference compared to what you got when listening to a distant station with your receivers in a sensitive condition. It is then in following out this idea that the designer from the power man's point of view has placed his reliance on ample signal strength to keep his signals well above the level of the interferences.

PROPOSED PLAN OF WAVE BAND ASSIGNMENT FOR BROADCASTING STATIONS

Station Class	No. Channels Available	Power Allowed	Wave Lengths Meters	Frequency kilocycles	No. Assgmts Same band	No. Time Divisions	No. Assgmts Possible
IV. (Waiting list)	4 of 10 kc.	100 w.	200—204	1500—1470	As required	As required	Unlimited
III.	45 of 10 kc.	100 w.	205½ 294	1460—1020	4	3	540
1.	15 of 20 kc.	5—50 kw.	300— 416.6	1000— 720	1	0	15
II.	17 of 10 kc.	500 w.	428½ 555	700— 540	2	2	68

The carrier current systems as now perfected work, so far as the individual talking over them is concerned, just like an ordinary automatic telephone system. The call is made by dialing and the conversation is two-way with nothing for the talker to do but talk and listen just as on a regular telephone line.

The radio waves are used as a substitute for the telephone wires and such differences in equipment as exist are due to the needs for such substitution.

Radio Broadcasting

In the fall of 1921 a new phase of radio operations was initiated and radio broadcasting was started. To Mr. H. P. Davis, vice president of the Westinghouse Company, is due the vision of such a service and later the courage and energy required to carry it through to a conclusion in the face of unusually discouraging conditions. There had been, prior to the Fall of 1921, a number of demonstrations of radio telephoning to distant points, but no one else saw the feasibilities of such a service or appreciated the economic possibility of rendering it. Even at the end of the first season, i. e., the beginning of the summer of 1922, many doubted its permanence and thought of it only as a passing fad. The fact that purchases of radio apparatus in the United States for 1924 totaled $500,000,000 is fairly conclusive proof that it is deeper seated in its popularity with the American public than even its most ardent advocates would have dared to forecast at the beginning. There is little that I can tell you, that you do not already know, as to the reasons for this tremendous popularity. It is here, however, and here to stay in some form or another.

In the spring and summer of 1920 Frank Conrad, Assistant Chief Engineer of the Westinghouse Company, had spent a considerable part of his spare time in experimenting on a radio telephone transmitting station. He transmitted phonograph records principally. Much to his surprise, the interest in this operation kept growing and he was called upon so frequently to transmit that he finally announced over the radio that he would send regularly, on Saturday nights, and then only and furthermore that he could use some new records if anyone cared to donate them. The interest around Pittsburgh among the radio amateurs grew to such an extent that by early Fall the department stores were advertising and selling receiving sets to listen to these Saturday night concerts. Mr. Davis got his idea from this experience of Mr. Conrad, and finally announced that he proposed to start a regular radio broadcast service at regular hours and every night with the expectation that it would grow to large proportions and that the expense of such operations could be charged against advertising and profits from sales of sets.

This has been done so satisfactorily that now the difficulty is to limit the number of broadcasting stations. It is getting to be like a large convention where everyone wants to talk and we are sadly in need of some parliamentary rules of order for radio transmitting. At present our laws do not provide adequate means of regulating such traffic, but before we can hope for a change in the laws there must be a plan which, first of all, is in the best interest of the listening public and second, which will take care, in so far as this is possible, of existing equipment. I am showing in the following tabulation a plan that I believe is workable and which has been designed from the point of view of the listener.

Radio relays on short wave channels in bands of 50 kc. width from reservations 50-55 meters and 60-65 meters, 70-75 meters.

In the tabulation the several classes of stations appear in the order of their wave lengths. It will be more readily understood, however, if it is studied in the order of the station classes. Class I is for a limited number of stations that can classify for a de luxe service.

Each of these stations is assigned an exclusive wave channel of 20 kilocycles breadth and permitted to use larger power, from 5—50 k.w. It is expected that general interest will exist in what each of these stations has to offer and it is desirable to protect them from interference to as great a degree as possible. Under favorable conditions it should be possible to listen to anyone of these Class I stations from any place in this country, with, of course, suitable receivers.

It is not believed to be difficult to prescribe a set of conditions that must be fulfilled to qualify for admittance to this class, to limit the number to the available wave channels. Such conditions should, of course, be based upon the theory that the listeners' interest is of prime importance.

Class II stations are those of less national importance and yet whose facilities entitle them to be ranked above and given superior opportunities than the stations in the lower classes. These stations should be required to fulfill certain specified conditions to entitle them to qualify for this service. The standard of this class should be maintained and none from lower classes admitted unless fully competent, regardless of the number of vacancies in this class.

Class III would contain that large number of small stations whose influence is very local. It is highly desirable that a number of such stations exist, as local color is needed in certain of the programs. Furthermore, these stations will render a service that to some is more pleasing than that from stations in the higher classes. This class of station is limited in power to 100 watts, in order to minimize its interference with other stations on the same wave channel, but located a sufficient distance geographically to cause little or no interference with the large majority of local listeners, i. e., the ones who can logically be assumed to be the regular listeners to that station.

The stations qualifying for this service will need to fulfill a less rigid set of conditions than those of the higher classes.

Class IV: This is the waiting list. Into this class all newcomers must go and await an opening to a higher class as a vacancy arises. Admission to this class requires compliance with the conditions for one or the other of the preceding classes. A newcomer seeking admission to one of the higher classes must prove its ability to meet the conditions of the class of station sought and must then wait its turn for admission to the higher class as vacancies occur.

This plan has been worked out on the theory, common to most public utilities, that if the public

is being adequately served at reasonable rates, it is not economical to permit a new competitor to enter that field and thus destroy, at least to a degree, the property of the original investor, who has developed the field to the joint benefit of those served as well as himself. Until some such assurance is given to those capable of developing broadcasting they cannot be expected to risk large investments which may be destroyed at the will of any competitor who seeks to enter the same field and who can do so only by the original operator dividing time with him. A third entrant would, of course, divide it again and the cost of the service be made three times as great.

Another principle that should govern in the selection of applicants for admission to the several classes, is the one of purpose in broadcasting. Of course, broadly, the purpose is advertising. But are they interested beyond that? Are they interested in developing the art of broadcasting? It must be apparent that the art of broadcasting has a better chance of growing and becoming a more permanent institution if those broadcasting are interested in developing broadcasting equipment and methods rather than simply trying to let you know that some particular article of merchandise entirely foreign to broadcasting is the best of its kind.

Provision is also made for reservations for radio relay connections, so that it may be possible for some of the Class III or Class IV stations to secure programs for their use and thus make them available locally to those listeners not equipped with the more sensitive receivers.

In all radio audiences there are those who have trouble with their receiving sets. Generally, this is interference from which they desire relief. Possibly a few suggestions may help some of you and some of the suggested remedies may be of service to you. The circuit is tuned, by means of the condenser, or inductance, to resonance to the interfering signal. In this condition it offers the best path to ground for the interfering signal and thus "bleeds" off the greater part of it and frees it from the receiving set. The condition of resonance is most readily determined by listening on the receiving set to some other signal and then adjusting the resonant shunt until the interference from the station to which the shunt is adjusted either vanishes or is a minimum.

The second method employs a so-called wave trap, i. e., a condenser and inductance in parallel and the two placed directly in the circuit leading to the receiver. When this circuit is in resonance to the interfering signal it offers a very great impedance to it and thus allows but a small part to reach the set. For other frequencies it offers but small impedance and so does not materially reduce the signal.

The third method is a neutralizing one, in which the interfering signal is picked up in a small system of its own tuned to the interfering signal and then made to oppose the signals picked up by the regular antenna. This opposition is secured by a coil so related to one in the receiving antenna as to position and polarity as to balance out the interfering signals.

As will be apparent, each of these methods is applicable to keeping out but one interfering signal, but they can be increased for each additional one by the employment of the same or other method a second. However, complications soon limit the pleasures secured in this manner.

The greatest degree of selectivity is secured by employment of the heterodyne principle. As used in radio telephone reception this set is called a "superheterodyne" because of the necessity of the so-called audible beat being at the supreme limit, or as now practiced, above audibility. This beat frequency, about 40,000 cycles per second, is then amplified by sharply tuned radio frequency amplifiers and passed to a detector and again amplified by one, or two stages of audio frequency amplifiers.

This set represents our limit of knowledge on selectivity and it can be made as sensitive as desired by adding amplifiers. We have no need of greater sensitivity, however, excepting as it is accompanied by greater selectivity. What is needed is a higher ratio of strength of signal to interference.

The desire to increase this ratio, and so have the signals come through strong with little or no underlying noise, is the prime cause of the increase in power so common among the older and more experienced broadcasters. It is not their purpose simply to get a louder voice to drown out other broadcasters. There is always an underlying noise level produced by various electrical appliances, such as motor commutators, leaky line insulators, X-ray machines, electric signs, etc., that is brought out if too much amplification is attempted. We can look forward then to increased power from the best stations.

Short Waves

One of the most important radio developments of the past year has been the employment of short waves in broadcast relay operations. This is important because, from a technical point of view, short waves are less interfered with by atmospheric disturbances; are produced with greater efficiency and are picked up at the receiver with greater efficiency; and at night their absorption is less than previous experience with somewhat longer waves had indicated it would be.

From an operating point of view the short wave system provides an excellent connecting link between stations to permit re-broadcasting. As an illustration KDKA has sent out the same program on two wave lengths, one the normal one for local use—though reaching frequently several thousand miles—and the other on short waves approximately 63 meters, which have been picked up in Hastings, Neb.; Manchester, England, and Johannesburg, South Africa, with sufficient clearness and uniformity to permit its being re-broadcast from each of those places. A recent test to South Australia has proved successful, although the time difference made it necessary for KDKA to transmit at 4 o'clock in the morning to correspond with the evening program in Australia. It is rather an interesting problem to determine whether it is the evening of the same day, the one before, or the one following. Remember that the date line is between Australia and the West Coast of the United States.

The short waves accomplish almost incredible things, and are, no doubt, capable of many more when we learn more about them.

The increased knowledge of vacuum tubes, without which we could not have the continuous waves of such length, has made possible the progress made thus far. As this increases we will go to shorter and shorter waves with the continually broadening horizon of possibilities.

Think of the increased number of wave channels made available by the short waves. While there are only ninety-six 10 k.c. bands between 200 and 555 meters, there are three hundred 10 k.c. bands between 100 and 50 meters; four hundred such bands between 50 and 30 meters, and five hundred between 30 and 20 meters.

We now have available within the present explored bands from 100 to 20 meters 1200 new wave channels.

One might reasonably ask why not open this to the broadcasters. It would be a great pity to do so, until we know more about them technically and determine in what service they can best serve the interest of humanity.

Future of Radio

Enough has been said of the past, what of the future? I make no claims to prophetic powers, but I have seen so much accomplished in this art where, as one of our ablest jurists has so aptly said: "The impossible of today becomes the commonplace of tomorrow," that I would hesitate to tell you what will not be done.

Developments of an art are always either evolutionary, or revolutionary.

The latter type are the kind that are most difficult to foretell, as they generally depend upon the discovery of some new principle.

Of the evolutionary kind we can undoubtedly expect a gradual improvement in reliability of service. We can look for a solution to that greatest of radio problems—the elimination of the effects of static. We will have loud speakers that speak understandingly—just like the original speaker were he present. We can look to the short waves for individual wave channels. With directed waves, as beams like light, there are about 150,000 10 k.c channels available between 20 and 5 meters, assuming the same wave channel repeated geographically four times and eight times at each point, as can readily be done when directed.

Short waves will be used for keeping in constant touch with watchmen and policemen. If radio increased the effectiveness of our Navy threefold, as stated by Admiral Mahan, what would it do to our police protection?

Undoubtedly remote control of various devices will be an important field, as will, also, that of the carrier current systems. We are now on the threshold of transmission of autograph letters and even photographs.

From still pictures we can look forward to the transmission of motion pictures. All that is needed is to do in 1/16 part of a second what is done with the still picture in 5 minutes. Quite an increase in speed, to be sure, but one or two little improvements may make it easy of accomplishment.

But what of radio broadcasting? Here there are both technical and business problems. The former will be solved and result in greater accuracy of reproduction; in freedom from troublesome interference and even in the combined reproduction of sound and sight. When this radio millennium arrives one can enjoy the football game in a comfortable chair at home and see as well as hear all that takes place.

The development of the business problems are not so apparent. Today the greatest problem of the radio broadcaster is his program. As the novelty wears off, the quality of program offered must improve or interest will lag. How can the artists be paid, as the best ones must, and the program manager keep within his budget? How can the broadcaster "pass the hat," or better still, sell tickets of admission? This must be accomplished in a way that will not be distasteful to those who pay and must be brought about by a realization on the part of those who pay that they are getting their full money's worth.

We will not always have with us so many broadcasters. It is an expensive practice and will gradually cause many to fall out. There are some now who would like a graceful way out and others who are holding on solely in the hope that they hold a squatter's rights in a wave channel which later can be sold at profit.

While I cannot see the form of the ultimate solution, I am satisfied there is one and that we have radio broadcasting with us as a permanent institution upon which we will lean more and more for our information and amusement.

Pressure Regulators at the Inland Steel Co.

By C. J. SMITH*

ABOUT four years ago we were experiencing a great deal of trouble on account of our feedwater regulators not functioning properly; also with high maintenance costs on our turbine-driven, centrifugal feed pumps and pump governors. After a thorough investigation we arrived at the conclusion that the major portion of this trouble and expense was caused by the excess pressure pump governor we were using. Several different makes of commercial governors were tried out, but none of them were sufficiently sensitive to maintain an absolutely constant excess pressure or to totally eliminate surging in the turbine driven pumps. (This surging and consequent pulsating pressures in the pumps was blamed by the pump builders for the high maintenance costs on the pumps). We also found that while some of the governors would function fairly well when properly

*Fuel Engr., Inland Steel Co., Indiana Harbor, Ind.

"tuned up," they would not "stay put" without constant attention.

At this time we conceived the idea of building the mercury-controlled pump governor illustrated in Figure 1, eliminating all counterweights, springs, stuffing boxes, etc., and their resulting friction and using a thin rubber diaphragm which has equal water pressures on both sides and which, at full stroke of the valve in either direction, fits the diaphragm case like the inner tube in an automobile tire without strain on the diaphram.

This first governor was constructed and put into

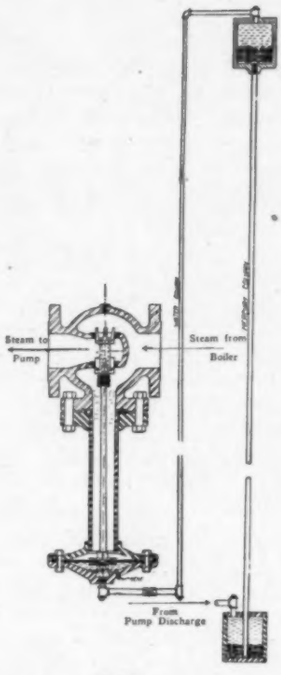


FIG. 1.

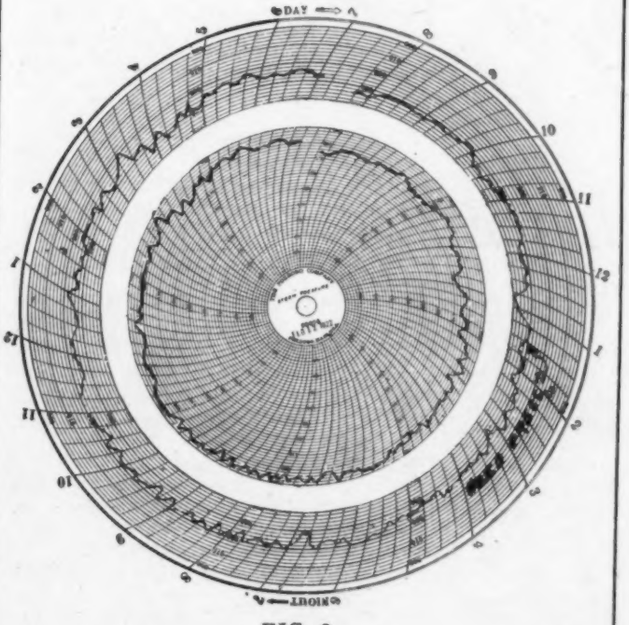


FIG. 2.

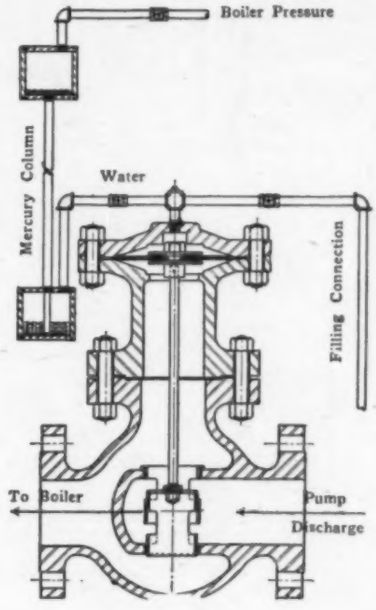


FIG. 3.

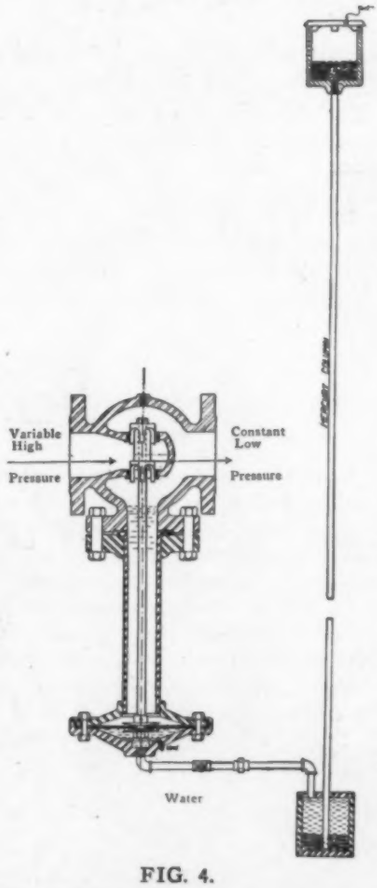


FIG. 4.

operation four years ago and to date it has not been touched and is still functioning perfectly. Figure 2 illustrates the excess feed water pressure maintained by this governor.

After all our pumps were equipped with these governors, our conclusion, as to the cause of our trouble, was proven correct, as 90 per cent of our

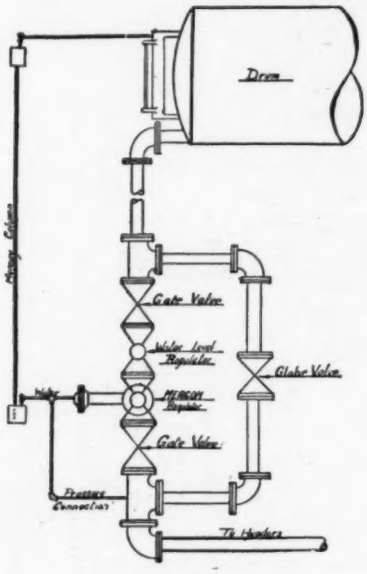


FIG. 5.

feed-water controller trouble and pump maintenance expense was eliminated, as well as all our governor trouble.

This same principle has been developed to handle regulation problems of various kinds.

Figure 3 illustrates its application as a throttling excess pressure governor for motor-driven centrifugal boiler feed pumps. At first thought this method of regulation appears wasteful, but unless the pump is driven by a variable speed motor with automatic pressure speed control, the pump is controlled anyway by throttling, if not at the pump discharge then at the feed-water regulator controlling valves. As the characteristic curve of most centrifugal boiler feed pumps is such that, throttled to 50 per cent of rated capacity, the efficiency only drops to about 75 per cent of the maximum, this method of regulation is far simpler, cheaper, more accurate and compares favorably in economy with any device controlling a variable speed motor to obtain the same result.

Figure 4 illustrates the mercury construction as used for a constant pressure regulator or reducing valve. If the valve as illustrated is installed in the steam line to forced blast fan engines or turbines with the steam flow in the direction opposite to that indicated by the arrows, it makes a sensitive accurate, reliable fan engine or turbine regulator.

In the present large boiler plant with large boilers and economizers operating at high ratings the friction drop, through the long feed lines and economizers, varies with the load and is quite different for the different boilers. In addition, the steam pressure drop through the superheater and piping varies with the load. The sum of these two pressure drops subtracted from a constant excess pressure at the boiler feed pumps gives a different pressure drop through the feedwater controlling valve on each boiler, and a pressure drop on each boiler controlling valve, which decreases with an increase of load.

This has prevented the proper functioning of the feedwater regulators in many of the large power stations and has led, in several cases, to the installation of one of the mercury-controlled regulators in connection with the feedwater controlling valve on each boiler to maintain a constant pressure drop through each controlling valve, irrespective of the boiler load.

Figure 5 illustrates the method of installing the individual boiler regulators in one of the large central stations.

These mercury-controlled regulators have been patented by the writer, and are being manufactured and sold under the trade name of MERCON regulators.

Items of Interest

Recently the Chicago district of the Association held an invitation golf tournament which resulted in one of the most satisfactory outings that the Chicago District has ever attempted.

This tournament occupied the entire day—was played at the Oak Hills Golf Club and the total day's fun consisted of golf in the morning, lunch at noon, golf in the afternoon, dinner in the evening.

The day was marked by some very outstanding features..

Mr. R. L. McIntosh, for the first time in his life, played 36 holes of golf and in the case of one of those 36 holes, he was on the green in two. (At least that is the report).

This tournament, we believe, holds the record for wide divergence in total scores—the lowest being 87 and the highest 187.

There was a large number of prizes available, due to the courtesy of many of the commercial companies allied with the Association membership. Mr. E. L. Upp of the Gary Tube Company, was extremely fortunate in winning a prize for the greatest number of lost balls.

Another fortunate player was Mr. A. A. Claassen of the Interstate Iron & Steel Company, who was awarded a very handsome prize for showing up with the loudest suit.

An interesting feature of the day was an auction sale of the six best players, who, after the selection had been made, played a couple of holes; the backer of the winner taking the entire proceeds of the auction. Mr. Forsstrum, Chief Engineer of the Wisconsin Steel Works, succeeded in capturing the money for his backer in this event.

Approximately 42 men attended this entire day's event, and it was the unanimous vote of the party that the whole affair was most enjoyable from every standpoint.

The Cincinnati Milling Machine Company, of Cincinnati, Ohio, has just designed and placed on the market several new types of milling machines, which are provided with tapered roller bearings automatic and centralized oiling systems, and which provide for rear control and convenient operation.

A sliding gear transmission, mounted in tapered roller bearings, and providing 16 spindle speeds, is the feature of these new machines. The tapered roller bearings bring about a smooth cutting action and enable the user to obtain a greater per cent of power through the elimination of friction. With this device the machine has a 15% greater cutting capacity, removing 15% more metal than previous designs.

In order to eliminate the old system of lubricating through individual holes, which resulted in the loss of considerable time and frequent overlooking of necessary parts, these new designs of milling machines are provided with automatic oiling. All the mechanism within the pyramid column of the machines, including the feed box, is automatically lubricated by means of a pump system. The knee, saddle and table of the machine are completely oiled from five stations, thus saving considerable time and assuring the oiling of all parts. The reservoirs and oilers are large and conveniently located, and can be filled in a short time with a large mouth oil can.

The power quick traverse on these machines permits of ease and speed of operation. On the plain type of machine this power quick traverse, operated by a single lever at the front of the machine, enables the table to travel in either direction at a speed of 100 feet per minute. The lever automatically stops when the operator's hand is removed.

On many milling jobs, and tool room boring jobs it is necessary for the operator to observe the action of the cutter from behind the machine. In order to facilitate such work a rear control has been designed which enables the operator to stand behind the machine and watch the operation without fear of inefficient work.

These high power machines are of rigid construction. The column, of pyramid form, gradually tapers from the overarm to the base. An enclosed Westinghouse motor drive is provided within the column for silent chain drive. Sixteen spindle speeds are provided by means of a sliding gear transmission.

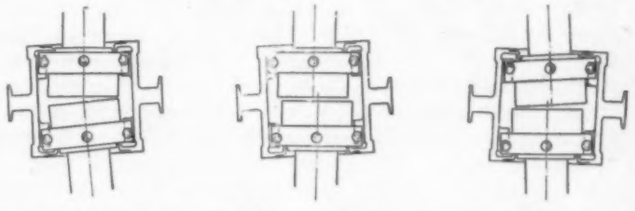
Full safety to the operator is provided for. The automatic spindle stop, operated by pulling the starting lever down, brings the spindle to rest immediately, while all universal joints are well guarded. The crank handles are provided with safety clutches, the teeth of which can be kept out of engagement. All starting levers are out of the way of the cutter, and the motor is completely enclosed.

The Fuller-Lehigh Company announce the closing of a contract last week, through their European representatives—Messrs. Babcock & Wilcox, Ltd., with the Societe D'Electricite de Paris, for a pulverized fuel installation at the St. Denis station, which will be by far the largest installation of this kind yet made in Europe. The St. Denis station is located just outside of the Paris city limits on the River Seine.

The boiler equipment consists of 8 B. & W. boilers, each of 1000 square meters (10760 square feet) of heating surface, producing 55 tons maximum of steam per hour each at 315 pounds pressure and 375 degrees Centigrade (707 degrees Fahr.) total temperature. The coal used will vary somewhat as to quality, but will have an average heating value of 6000 calories (10800 B.T.U. per pound), with about 12 per cent volatile, 20 to 22 per cent of ash and 5 to 10 per cent of moisture, with ash fusion temperature of 1140 degrees Centigrade (2084 degrees Fahr.).

The contract includes two 6'-6"x50'-0" Fuller Indirect Fired Rotary Dryers, three 70" Fuller Screen Mills, four 8" Fuller-Kinyon Pumps and Transport System for conveying the pulverized fuel from the milling plant to the boiler bins, together with Fuller feeding and burning equipment.

A new type of shaft coupling has been put on the market by the Farrel Foundry & Machine Company, Buffalo, N. Y. This coupling is designed to take the place of the usual type of flexible coupling. It is called by the makers the Sykes Universal Shaft Coupling because it differs from other flexible couplings in that it is really a universal joint and is, therefore, capable of not only taking care of small



errors in alignment, but will also successfully connect shafts which are grossly misaligned. Its limit of angularity is stated to be 5°. It will also connect shafts which are offset as much as 4% of the shaft size. For instance, a coupling made for a 4" diameter shaft will allow an offset up to as much as .16".

The accompanying illustration shows a coupling with a portion of the outer shell cut away, so that its detailed construction is readily understood. It will be seen from the illustration that the coupling consists mainly of three parts. It is, therefore, what is known as a three-element coupling. Two of the elements are in the form of hubs, one adapted to key on the driving shaft and the other on the driven shaft. The third element is made in halves and forms a sleeve, connecting the other two elements. The actual connection, however, is by means of balls bearing in races or grooves formed in lugs. It will be seen from the illustration that one set of lugs is on each of the hub members and corresponding lugs, inwardly projecting, are on the sleeve member. The sleeve member is made in halves for convenience during installation. The three diagrammatic figures show the action of the coupling when operating under the three possible conditions of misalignment. It will be seen that the balls can take up a suitable position in their grooves or seatings so as to give true, uniform rotation, irrespective of the amount of mis-

alignment. Therefore, the coupling is a true, universal joint. And it is claimed by the makers that universal action is the only requirement necessary in any so-called flexible coupling.

This new coupling is not designed to give torsional resiliency. It can be made by a slight modification to provide resiliency, but the Farrel Foundry Company do not advocate a coupling embodying this feature.

All parts of the new coupling are made in steel, of especially hard nature. The balls are standard, hardened steel balls, as used for the highest quality ball bearings. They have, therefore, an enormous resistance to compression.

It may be thought on superficial observation that there is danger of the balls or the ball races wearing rapidly. It should be observed, however, that the balls do not function like balls in a ball bearing. If one of these new couplings is mounted in true alignment the balls will have no movement. If a coupling is operated under conditions of maximum misalignment each ball will have a movement of about 1/32" per revolution. Therefore, the velocity under the worst circumstances is very low, and the conditions of operation are more analogous to the ball bearing in a crane hook than to a ball journal bearing.

Although this new coupling has only recently been put on to a production basis, a great many have been made during the past two years. The Farrel Foundry Company has taken special pains to apply these couplings for use under the worst possible conditions of service. They have been used for a wide variety of applications and have been thoroughly tested in actual work. Many of those installed have been in use for nearly two years, twenty-four hours per day, seven days a week. And not a single one has so far shown the slightest sign of wear or deterioration. Due to this wonderful record, the makers have designed very special manufacturing equipment and are now making couplings on a very economical production basis, which enables them to offer the couplings for general use and for any application where a shaft coupling is required which will prevent any stress on bearings due to misalignments and which will also not transmit any axial movement from one shaft to another. It will be observed from the illustrations that the construction of the coupling provides free axial movement of one shaft relative to the other. It is, therefore, extremely useful for connecting electric motors to driven shafts, because it permits of axial movement of the armature without any appreciable resistance.

The new coupling is at present standardized for shafts from ¾" diameter up to 8" diameter. Larger sizes will be manufactured later. The 8" coupling will transmit 1200 H.P. per 100 RPM. The makers issue a list giving all dimensions and power transmitting capacities.

Due to the use of balls as the power transmitting medium the question of lubrication is not important. The balls have such a slight movement that a film of grease is ample lubrication. In fact, it is claimed that even if all absence of lubrication should take place the coupling will not suffer serious damage.

A careful analysis of the action of this coupling shows that, irrespective of the amount of swivel of one member relative to the other, the balls have a line contact with their races. That is to say, each race is substantially semi-cylindrical and each ball always has a full line contact with two races, therefore, giving a line contact on the ball over nearly the whole of its circumference. Actually the races will deform under pressure from the ball and, therefore, give an appreciable load carrying area. The deformation, however, is always well within the elastic limit, so that no permanent deformation ever takes place.

The Brown Instrument Company, Philadelphia, Pa., have issued a new Catalogue No. 74, describing Brown's recording pressure and vacuum gauges. This catalogue tells you what recording pressure and vacuum gauges can do for you. Catalogue will be forwarded to you upon request.

The Republic Flow Meters Company, General Offices 2240 Diversey Parkway, Chicago, have issued an attractive four-page circular illustrating the construction and operation of the new Republic Multiple draft indicator. The chief point of interest in connection with this indicator is that all readings are on one eye level, thus making for the greatest possible ease of reading. The zero setting is permanent for each unit, and practically no upkeep is required, as a non-volatile oil is used in the seal. Its usual application is described on the first page of the circular. This draft indicator can be supplied to give any combination from 3 to 12 units of drafts or pressures not exceeding 8 inches of water, thus the best combination for the particular installation can be conveniently furnished.

The Martindale Electric Company, Cleveland, O., are offering to the trade an etching machine which is operated electrically. This machine has many valuable uses in the steel industry and the many practical demonstrations that were offered to the engineers at the

Iron and Steel Exposition in Philadelphia proved that every tool room should have one of these machines. No electrical superintendent's repair shop nor any master mechanic's tool room can afford to be without this

machine. There are no complicated parts, simple to operate and serves many purposes.

An important departure from conventional floodlight projector design is represented by the Pyle-National type No. 2375 projector. Ventilation has been entirely dispensed with and the cast aluminum alloy case has an absolutely tight closure, with machined surfaces at the door joint and a soft lead packing ring. The principal causes of depreciation in reflective values, and of lamp failures are eliminated, since dust, gases, moisture and insects are entirely excluded from the interior of the unit.

Ventilation is unnecessary in this new design, for the sufficient radiating surface insures perfectly safe interior temperatures for the glass reflector and lamp when using 1000 and 1500 watt lamps.

The case is of cast aluminum alloy, with a drawn aluminum back, and fittings and small parts are of aluminum or bronze. The mounting base and trunnions are provided with locking devices so that adjustment of the unit is not disturbed by the maintainer. Focusing is from the outside of the case. Pyle-National "Nonglare" or crystal glass reflectors 23" in diameter are used, and these, as well as the rectangular divergence lenses which are optional on this unit, are exclusive developments of the Pyle-National Company.

The type No. 2375 projector is the latest addition to a complete line of cast aluminum floodlighting and locomotive headlight products manufactured by the Pyle-National Company of Chicago. Descriptive bulletin with tables of illumination intensity and range, and other operating data, will be furnished upon request.

An improved type of Timken Tapered Roller Bearing, differing from the well-known Timken Bearing in major refinements but retaining all essential elements, which have characterized Timken tapered design, is now in production.

Nickel-molybdenum steel, of special Timken formula, has been adopted for all bearings. The inclusion of the alloys, nickel and molybdenum, produce a steel possessing properties of grain texture, toughness, hardening, heat treating and machining which reflect favorably in the life of anti-friction bearings.

Varied refinements in the bearing itself are noteworthy. The design of the roll has been changed so that the surface of the large end presents a right angle relation to the center line of the roll. The contact then between the large end of the roll and the rib of the cone is in two areas. The rib of the cone being slightly undercut. This two-area contact insures perfect axial alignment between the center line of the roll and the center line of the bearing at all times. Likewise there is always absolute line contact between the surface of the roll and the surface of the cone, and between the surface of roll and the surface of the cup.

An added purpose served by the two-area contact is self-alignment of rolls on cone, in the cup without resorting to a cage fixture to retain the alignment. The primary purpose served by the cage is to retain the rolls, properly spaced about the cone and to make the cone with its set of rollers a unit assembly. The skewing of the roll on the cone raceway is impossible, since the two areas on the end of the roll make generously separated points of contact with the shoulder or rib of the cone.

The Timken cage has been improved along with the cone and roller assembly. Previously, the cage was cold pressed into the shape of a cup, the bottom stamped out and the pockets for the rolls punched out, one at a time, by an automatic punch press. The result of this single stamping operation was positive uniformity of cage pockets, yet a progressive error in alignment, due to stretching of the metal, as the indexing fixture advanced the metal cage to the final perforation. To correct this microscopic error, a multiple perforating die was developed which perforates all roll pockets in the cage by a single impact. To further safeguard against any possibility of error during this operation, due to distortion, an inwardly turned flange has been retained on the smaller side of the cage. To insure smoothness and a perfect fit of the rollers in the cage the lateral edges of the cage are swedged inward so that the contour of the sides of the cage pocket conform to the contour of the roll. This operation is termed "winging." Dies similar to the multiple perforator are used, so that all cage pockets are winged simultaneously.

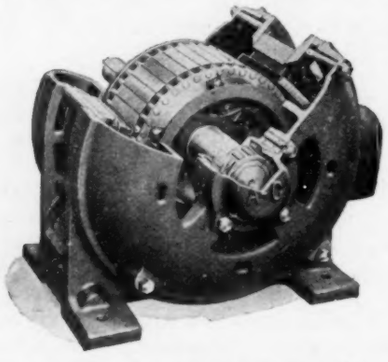
With the advent of more quietly running parts in certain machine installations the Timken Company has kept pace by reducing the noise in the bearing to a very marked degree, by the self-aligning principle and the accurately perforated cage. These special installations require a very definite uniform standard of quietness. To accomplish this uniformity, specially tested bearings are required. For this purpose an electrical sound testing machine was developed which measures the noise in a running bearing by means of an electric current. A sounding box connected to a telephone receiver, and a set of radio tubes, carry the amplified noise vibrations of a running bearing to a galvanometer connected to an arbitrarily indexed dial. The human element is removed entirely, the noise being registered with unfailing accuracy on the dial where it can be read by the operator. By the use of this machine it is possible to select bearings to a set standard suitable for the most quiet applications, as well as to locate the cause of the noise.

Although the Timken Bearing in use for a number of years showed a remarkable low coefficient of friction, yet the improved type has reduced this materially. The self-aligning properties of the rolls to the cone face admit much higher running speeds. The nickel molybdenum alloy steel, of special Timken formula reduces wear, so that in most cases the initial adjustment need never be disturbed. These various refinements make the improved Timken Bearing specially adaptable to all industrial uses, and particularly to high speeds common in machine tools. The tapered construction of cone, cup and rollers is retained, since this is the only type of construction which will carry successfully loads both radial, thrust and combinations of the two without resorting to thrust washers or special thrust bearings.

After two years of experimental and development work, the Allis-Chalmers Mfg. Co., Milwaukee, Wisconsin, has placed on the market a complete line of twenty-five and sixty cycle squirrel cage and slip ring induction motors equipped with Timken Tapered Roller Bearings. This is in addition to the company's well-known line of sleeve bearing motors. The Timken bearing was selected only after very

careful consideration of the many questions of design and operation. After designs of bearings and mountings had been made, a number of motors of various sizes were built and tested under actual operating conditions of belt, gear, chain and coupled drives, a sufficient length of time to insure satisfactory service before the line of motors was offered to the trade. The Timken Tapered Roller Bearing has been used because of its ability to withstand continued heavy radial and thrust loads without undue heating or appreciable wear. It is particularly suited to heavy service and will operate satisfactorily at the high speeds found in the general purpose induction motor. Because of the rolling action of the bearing, there is practically no wear so that the factory adjusted air gap is maintained indefinitely, eliminating any possibility of the rotor striking the stator.

The important question of lubrication is greatly simplified, as grease is used, requiring very infrequent



attention on the part of the operator. This is a very important point, because it has been found from experience, that a great many motor troubles can be traced to improper lubrication. The bearings have grease tight enclosures effectively excluding dirt or abrasive matter that might cause undue wear of the bearings. The mounting of the bearings is very simple, being only a light press fit for both the cone and cup, and not requiring the use of a lock nut or other means of holding the races in place. This also facilitates the removal of the bearings whenever necessary.

The Timken Tapered Roller Bearing is nationally known, and has been used very extensively in the automotive field for many years, where its operation has proven very satisfactory, as many automobile owners know. The engineering, manufacturing and service facilities of the Timken Roller Bearing Company are now being directed to the field of motor applications, assuring results as satisfactory as in the past in other fields.

In addition to the bearings, special attention has been given to many other features of design of this line of motors. This motor has to meet the many severe conditions found in its application to the various types of machinery manufactured by the company. The frame is made of steel with feet cast integral, to withstand shocks encountered in use with the company's crushers, grinders and other machinery. In applying the motors to the company's centrifugal pumps, very often severe conditions of moisture are met so that the coils are thoroughly insulated and baked in a water-proof varnish. In saw mills, flour mills and cement mills, motors must operate in very dusty and dirty places, so that the scheme of ventilation must successfully meet these conditions. The openings in the housings and frames for ventilation are so placed in vertical planes, that falling objects cannot enter the motor. The roller bearing motor is particularly adapted to many applications because the overall length is considerably less than for a sleeve bearing machine. Inasmuch as this line of motors must meet the exacting requirements of application to the company's own machinery, the general buyer benefits because these special features are incorporated in the manufacture of all the motors produced by the company.

This motor equipped with Timken Tapered Roller Bearings can now be obtained in all ratings, twenty-five and sixty cycle, 200 HP. and smaller.

The Cutler-Hammer Mfg. Co. has purchased the business and patents of Paynes Dean, Limited.

The Dean Valve control apparatus has always been manufactured by The Cutler-Hammer Mfg. Co., and they have recently also manufactured much of the other equipment sold by Payne Dean, Limited, such as the auxiliary power plant apparatus, including Dean Signal Systems, switchboards, load indicators, etc.

The Cutler-Hammer Mfg. Co. will continue the development and manufacture of these devices, and will also market them.

Mr. Dean and many of his associates are now connected with The Cutler-Hammer Mfg. Co., and will actively assist in the promotion of this work.

Future communications should be addressed to The Cutler-Hammer Mfg. Co., Boston, New York, Philadelphia, Buffalo, Pittsburgh, Cincinnati, Cleveland, St. Louis, Chicago, Detroit or Milwaukee, as may be most convenient. Inquiries from the Pacific Coast may be directed to The H. B. Squires Co., Los Angeles, Portland, San Francisco or Seattle.

By the acquisition of this business The Cutler-Hammer Mfg. Co. hopes to serve the industry even more effectively than has been done in the past.

"Capacitors" is the title of a 24-page bulletin, just issued by the General Electric Company, describing the value of this device in power factor correction on electric generating and distribution systems and for direct installation at motor terminals on low voltage circuits. Details are given as to operation, location, etc. Illustrations in the form of charts, diagrams, tables and photographs are used. The bulletin bears the designation GEA-77.

Effective August 24, the plant, property and good-will of the Strom Ball Bearing Mfg. Co. have been acquired by the Marlin-Rockwell Corporation.

The business of this company will be conducted exactly as heretofore, under the direction of the same personnel and department heads. There will be no change in the policy or the conduct of the business. The same lines of bearings under the Strom trade name will be continued as at present.

All correspondence in the future should be addressed to the Marlin-Rockwell Corporation, Successor to Strom Ball Bearing Mfg. Co., 4535 Palmer Street, Chicago.

A new type of double range Scherbius drive, apparently the first of its kind, will be installed by the Trumbull Steel Company, at Warren, O., in connection with an installation of electrical equipment for driving part of a 16-inch hot strip mill.

The complete equipment will include the usual steel mill type of motor (an induction machine rated 5000-4000-3000 horsepower, 450-360-270 r.p.m., 2200 volts) and a complete regulating set, all of General Electric manufacture. The motor will be equipped with six collector rings, each end of the three secondary phases being brought to a collector ring. The motor shaft will be extended at each end, at one end for coupling to the gear unit and, at the other, for mounting an ohmic drop exciter rated 14 k-va., and running at the same speeds as the motor.

The regulating set will consist of two machines, each 480 kv-a., 514 r.p.m.; a synchronous motor rated 1175 horsepower, 514 r.p.m., and a d-c. exciter rated 18 kilowatts, 514 r.p.m., 125 volts, for supplying excitation to the synchronous motor fields. The synchronous motor will replace the usual induction motor, thus providing operation at the maximum possible power factor. The synchronous motor will be started in the usual way by means of an auto-transformer used in conjunction with the switchboard.

The two regulating machines allow a higher speed to be used for the set, each unit being one-half the required capacity. A further advantage is that, by the use of this equipment, a much lower secondary current is developed in the main motor, permitting the use of smaller contactors and resistors of lower current capacity, making the installation work less difficult.

Should it be necessary to remove one regulating machine from the group, the electrical circuit to that unit can be removed and suitably connected, three of the collector rings will be shorted and the equipment will operate with one regulating machine, one-half the total regulation being thus obtained both above and below synchronous speed.

The new Bulletin No. 2045 on Pittsburgh Distribution Transformers, Single Phase and Polyphase, has just been made ready for publication. This book is one of the most complete and comprehensive publications on transformers ever issued, covering, as it does, information that has never been published except by the Pittsburgh Transformer Company.

The forty pages contain descriptions and photographs of Pittsburgh Distribution Transformers, together with diagrams showing test connections and a schedule of approximate dimensions of all sizes and voltages of distribution transformers from 1½ Kva to 200 Kva, 440 volts to 44,000 volts, Single Phase and Polyphase.

The information contained in Bulletin No. 2045 will be of value and of every-day use to operators of transformers, the dimension being of special interest in laying out installations.

Additional copies for any engineer or anyone interested in the purchase and operation of transformers who has not received a copy of his book shall be sent gladly on receipt of your request.

After more than a century of continued production, respectively by hand, water and steam power, the historic Phoenix Iron Company, at Phoenixville, which played important parts in the World War, the Civil War, and even during the early days of the Republic, will change entirely to electrical operation.

A contract for equipment in excess of $250,000, necessary for the electrification of the huge 36-inch "bloomer" mill, has been awarded to the Westinghouse Electric & Manufacturing Company, including the main mill motor, the fly-wheel set and auxiliaries, weighing more than half a million pounds. The new apparatus will increase the electrical equipment of the plant by 4,350 h.p., and is an addition to the Westinghouse drives for the 22-inch and 24-inch structural mills installed last year.

In recent years, in addition to steam and hydraulic power, electricity has been gradually applied to the various machinery units at the plant, now culminating in the electrification of the "bloomer" mill. This mill is capable of rolling 12,000 pounds of ingots into "blooms" or "structural" blanks of an average weight of 180 pounds per lineal foot, at the rate of 30,000 tons per month, charged weight. A 3,500 h.p. Westinghouse reversing mill motor with the range of one to one hundred and twenty revolutions per minute will be required for the operation of this mill. How huge this single motor is may be gained from the fact that its weight is 300,000 pounds. The length of the motor is 19 feet by a height and width of 17 feet. Electric current for the operation of this motor will be produced by a 3,000 Kw. generator, driven by a 2,500 h.p. motor, coupled with a 60,000-pound flywheel. When running at full speed, the flywheel is releasing stored power to the extent of 1,000 h.p., thus bringing the total up to the same as acquired for operating the mill motor at full capacity.

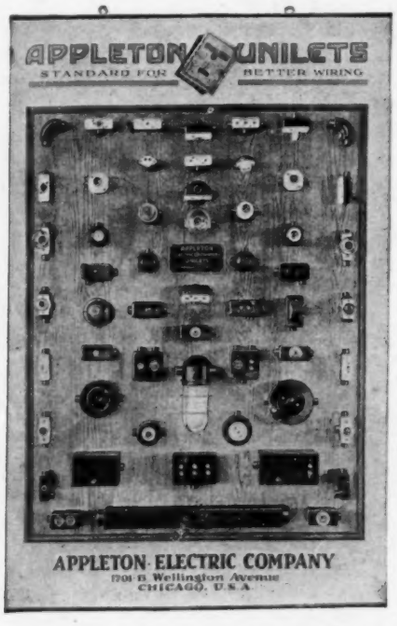
Auxiliaries required for the mill drive, in addition to the main motor, includes eight motors and two blowers of "air washers," each of a capacity of 30,000 cubic feet per minute, while separately, the contract calls for the delivery of three extra motors of a total of 850 h.p. for the operation of water pumps.

When installed this will represent one hundred per cent electrification of the mill drive, and ninety per cent electrification of the steel plant as a whole, carrying out the company's policy of supplanting steam and hydraulic power with electricity.

The Chicago Steel and Wire Company has issued a treatise on the properties of steel filler rods for gas and electric welding. Most of the subject matter will be found to be new in whole, or at least so far as its significance to the welding industry is concerned. The subjects treated are as follows: The Meaning of Iron and Steel, Method of Manufacturing Filler Rods, Manufacturing Differences Between Filler Rods for Gas and Electric Welding, Causes of Weld Failures, Gas in Filler Rod, Hydrogen, Water, Heat Treatment During Manufacture of Filler Rods, General Significance of Chemical Analysis, Effect of Analysis on Gas Filler Rod, Effect of Analysis on Electric Filler Rod, Flux Coatings, Cast

Iron Filler Rod, Alloy Steel Filler Rod. A copy of this booklet may be obtained by writing the Chicago Steel and Wire Company, One Hundred and Third Street and Torrence Avenue, Chicago, Ill.

The Appleton Electric Company, 1701 Wellington Ave., Chicago, Ill., have had printed a very attractive wall hanger on Unilets "steel conduit fittings."



This is 21½x32¾ in size, printed in attractive colors, and will be sent to any electrical engineer on request.

The largest steam condenser ever conceived by engineers, to be operated in conjunction with a 115,000 H.P. generating unit, larger than any other single unit constructed in the history of the world, has been ordered by the Brooklyn Edison Company, according to an announcement issued at the South Philadelphia Works of the Westinghouse Electric and Manufacturing Company. The condenser and turbine equipment will be made at the South Philadelphia plant, while the electric generator will be delivered from the East Pittsburgh Works, the whole installation calling for an outlay of more than one and one-quarter million dollars. The contract calls for the delivery of all the equipment to be made at the Power Plant in Brooklyn early next spring.

When completed this engine will be about fifty times as large as the biggest steam units produced twenty-five years ago. The total weight of the generating unit will be one and one-quarter million pounds with an additional 1,000,000 pounds for the condenser. The low pressure spindle, or rotor, alone will weigh 126,900 pounds, exceeding by thousands of pounds the biggest spindles ever made anywhere before.

The spindle, when the turbine is in full operation, will make 1,800 revolutions per minute, while the lubricating problem was one of the most important for the engineers to overcome in designing this engine. The largest unit built heretofore was one of 70,000 kw., or approximately 95,000 H.P., which was installed in the Power Plant of the Interborough Rapid Transit Company, New York City.

The condenser ordered for use with this new unit will have 80,000 square feet of cooling surface, or 10,000 square feet more than the giant condenser completed a few weeks ago by the South Philadelphia Works for the new Port Richmond Station of the Philadelphia Electric Company. When completed the condenser will contain 12,920 tubes, each 24 feet in length, or equivalent to a continued tube length of 58½ statute miles, six miles more than the Port Richmond condenser. The length of the shell will be more than thirty-four feet, while the height will be about the same as an average two-story house. The condenser will be equipped with two immense pumps of a combined capacity of 100,000 gallons per minute, or close to 150,000,000 gallons per day, when operated the full twenty-four hours.

The American Heat Economy Bureau, Inc., Pittsburgh, Pa., reports the sale of Steinbart Burners to the following Steel Companies: Tonawanda Iron Corporation, North Tonawanda, N. Y., 4 Stoves; Inland Steel Company, Indiana Harbor, Ind., 4 Stoves; Bethlehem Steel Company, Lackawanna, N. Y., sixth repeat order, 4 Stoves; Otis Steel Company, Cleveland, O., third repeat order, 4 stoves, 4-834 H.P. Boilers, 2-500 H.P. Boilers, 1-100 Ton Open Hearth Furnace. The orders from the Otis Steel Company, are particularly interesting, as the whole Blast Furnace Plant will now be equipped with Steinbart Burners.

A new truck and trailer crane is now being placed on the market by the Harnischfeger Corporation (formerly Pawling & Harnischfeger), of Milwaukee, Wisconsin. This crane—known as the P&H Model 203-A Truck Crane—is the final result of a long series of tests and developments made by the P&H Engineers, and the machine now embodies the valuable combination of speed, compactness, light weight, sturdiness and complete accessibility. The great value of these features are better realized when considered along with the advantages which they give in the operation of this crane.

The speed of this crane can be especially appreciated when moving between jobs. The truck or trailer mounting enables it to move at regular truck speed, thus cutting down the inactive time to a minimum. This is especially advantageous when there are a number of jobs, all at different points. When on the job, it is equally fast in operation—having a line speed of 125 ft. per min., and a swing speed of 5 R.P.M.

Compactness is achieved mainly by the simple arrangement of having all three drums mounted on one shaft. The hoisting and digging drums are mounted side by side and the boom hoist is placed on the end of this shaft, at the left side of the machine. This arrangement of machinery makes it possible to have every piece of main machinery behind the center pin, thus giving better balance and eliminating the necessity of a large amount of counterweight (only 1,000 lbs. being used). A more concise idea of the compactness of this machine may be gained from the fact that there are only four shafts on the whole machine and only eleven main gears and a set of planetary gears. Simplicity is thus combined with compactness. This type of construction gives the very short tail swing of 7′ 1½″ and an overall width of 8′ 4″. Thus the machine is able to work

in very close quarters, or to travel in very narrow alleys without interference.

The light weight of this machine is realized at once from the total weight of 13,000 lbs. This weight includes the entire crane equipment with the structural frame which fits on the truck, but does not include the weight of the truck.

This light weight makes it possible for a 5 or 7½-ton truck to handle the crane and also reduces the danger of miring in soft ground.

Sturdiness on this Truck Crane is obtained by cast steel revolving frame, cast steel drum-bearing frames, heavy swing gear with I-beam spokes and outside teeth. Thus there are no rivets to work loose and the frames are always rigid.

The accessibility of this machine is as complete as possible. Any shaft on the machine can be removed without disturbing those adjacent. Every

gear and bearing can be readily reached for lubrication and care. The revolving rollers can be removed from the top of the frame without jacking up the machine. Drum clutches and all brakes are of the outside band type, making adjustments and renewals very easy.

This machine is built to handle a ½-yd. clamshell bucket on a 25-ft. boom, or for lifting 10,000 lbs. at 10-ft. radius.

The machine is driven by a 4-cylinder, 40 HP motor, which operates at a governed speed of 1,000 R.P.M. The motor is placed at the rear of the revolving frame and is entirely accessible for care and operation. The radiator is of the cast-tank type, with a corrugated core of large frontal area. A centrifugal pump is used for forced circulation. Motor lubrication is by pressure feed to all main and connecting rod bearings—a geared pump with removable screen being used. The gasoline tank is a steel drum, of 20 gal. capacity, fastened to tne rear of the "A" frame.

The motor clutch is Twin Disc type, fully enclosed and supported in ball bearings. All the gears are made of high-grade steel with double cut teeth The first reduction gears are enclosed and run in light grease.

The two main drums are mounted side by side on the drum shaft and are controlled by independent clutches and brakes. Both drums run at the same speed, making it possible to use a clamshell bucket without special attachments and making is possible to open or close the bucket at any point. The drum clutches are controlled by the P&H Patented Power Clutch Control, which causes the motor to do the heavy work of operating the clutches.

The boom hoist is located on the main drum shaft, and is driven by planetary gears at a line speed of 62½ ft. per min. In lowering, the line speed cannot exceed 125 ft. per min., because of a self-locking connection to the drum shaft. Thus it is impossible to drop the load unless the cables part. A large outside band brake is provided for locking the boom hoist. This boom hoist can be operated at the same time as, or independently from, the main drums and swinging machinery.

The four main levers are grouped in a unit stand at the right hand, front of the machine, enabling the operator to sit and face the work, as well as see the operating machinery.

The revolving frame is a one-piece steel casting, heavily ribbed, providing a very rigid base for all machinery. The swing gear is of large diameter and has outside, non-cloggable teeth. A special structural frame is provided for fitting on the truck.

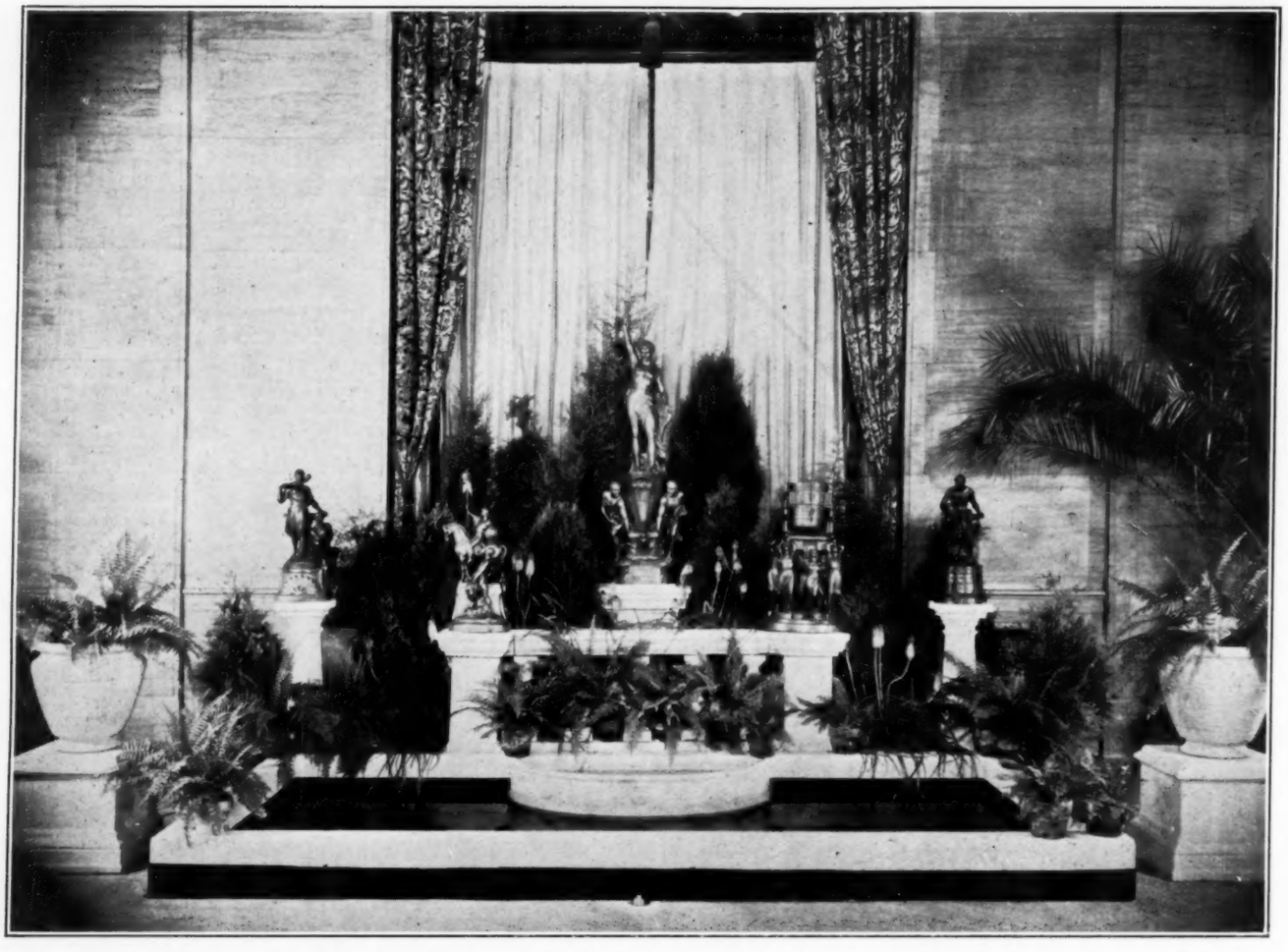
When the trailer mounting is used, the advantage of mobility is possessed, as well as the additional advantages that it releases a truck for hauling services and requires a considerably smaller investment. The trailer crane is provided with mechanism to propell itself at a speed of 1½ miles per hour when on the job. This is accomplished by a center drive shaft and two driving chains, connected by jaw clutches to the drive shaft. Brakes are also provided to hold the machine in position. All control of these clutches and brakes is centered on the upper frame convenient to the operator.

On both truck and trailer cranes, jacks are provided which screw down against the rear wheels. These relieve the springs of all load when the crane is operating. Chains pass from the jacks, around the wheels, acting as rebound snubbers.

An all-steel canopy and back shield with heavy canvas curtains is provided as standard equipment.

This truck and trailer crane may be equipped with clambshell or dragline bucket, crane hook, electric magnet or pile driver, and thus may be used for a wide variety of purposes. Handling coal, sand, gravel, pipe, poles, lumber, stones, snow, coke or steel is only a part of the many duties which may be performed by this machine.

The Harnischfeger Corporation has issued a complete bulletin covering this truck and trailer crane, copies of which may be obtained by request to any of their offices.



Safety Trophies of the Carnegie Steel Company, Pittsburgh, Displayed in Connection with the Fourteenth Annual Congress of the National Safety Council at Cleveland, Ohio, September the Twenty-eighth to October the Second, Nineteen Hundred and Twenty-five, in the Lobby of the Hotel Cleveland, Through the Courtesy and Co-Operation of the Management, and with the Artistic Design and Facilities of the Gage Gallery of Cleveland.

IN DISPLAYING these Safety Trophies to the Congress of the National Safety Council, and the citizens of Cleveland, the Carnegie Steel Company, of Pittsburgh, gives expression to the hope that the spirit of competition in safety work in industrial plants may be found by others an inspiration to new efforts in the reduction of accidents, and that employes may, with renewed interest, find a zest in entering into the effort of trying to excel in that noble spirit of who can best work and who can best serve.

Safety, ranks with production in Carnegie Steel Company plants, and a highly efficient organization is maintained for the study of the subject. This organization, through general and sub-committees, reaches out into every department of eleven manufacturing plants, an extensive railroad system, and a great tonnage carrying river transportation system. Every employe is made to feel that he is a vital part in a campaign that interests him, and soon he is imparting that spirit to his neighbor.

The work has just begun when all hazardous machinery has been guarded. Safety work is never finished. With the human element, the greatest results of safety work are met. It is the educational side of safety work that interests and holds men, and it is the educational feature that makes a safe workman; the best safety device in all industry.

And it is the educational phase that inspired these trophies. In 1920 the idea was conceived that men strive in contests when there is something at stake. The spirit of sportsmanship is inherent in every man. Therefore why not make the safety work a game? Put it on a competitive basis? The idea took root, and after much thought and search for a suitable goal or award, the bronze trophy was decided upon.

Mr. Guiseppe Moretti, of Florence, Italy, an eminent sculptor, who was in Pittsburgh at that time, became interested in what he termed the opening of a new field in art, and he undertook to design a trophy. This required much study on Mr. Moretti's part, for no attempt ever had been made to symbolize Safety. Mr. Moretti spent a year in study of this abstract subject and finally produced the trophy for 1922.

Immediately the spirit of competition manifested itself in the attitude of the men in the plants, and in the safety records with their reductions. So keenly did some men feel over their department records that it was taken as a personal affront when a comrade sustained the slightest injury. It readily was demonstrated that the idea of competition was a success, and with each yeear it grew. In the meantime, Mr. Moretti continued his studies so that annually thereafter he presented a composition covering a new phase of safety, until reaching a climax in the trophy for 1926.

The basis of award was a problem to be mastered. Because of the difference in the number of men employed in each plant, and the varied kinds of work, a just and fair basis was reached by having each plant compete against its own record for the preceding five years. This plan has worked out very satisfactorily, and is the basis now maintained. The plant making the greatest percentage of reduction in lost time accidents in a month holds the trophy for the succeeding month, and the plant making the greatest percentage of reduction over its own record for the preceding five years, at the end of the year is awarded the trophy in perpetuum.

Th 1922 trophy is owned by the Edgar Thomson Works, located at Braddock. This plant had a reduction of 85.53% over it average percentage of lost time accidents for the years 1917-1918-1919-1920 and 1921. The percentage of accidents to average force employed being used as a basis for calculation. The Farrel Works, at Farrell, Pa., won the trophies for 1923 and 1924, and now holds possession of them. For 1923 this plant had a reduction of 84.28% over its average percentage of lost time accidents for the years 1918-1919-1920-1921 and 1922; while for 1924 it had a reduction of 84.36% over its average percentage for the years 1919-1920-1921-1922 and 1923.

A reduction of 86% in lost time accidents has been made by the Carnegie Steel Company since it started its safety educational work in 1911.

Is it worth while? The Carnegie Steel Company, with its wide experience in safety work, declares that it is. Does it pay? It pays an hundred fold. It pays not alone in dollars and cents, but it pays in benefits to humanity. It pays in building citizenship. It pays in making better workmen, for the safety education work makes men think, for themeslves, for their families, and for their neighbors. It gives them a broader viewpoint of life. It makes them realize that they are a part of the scheme of Life.